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NATIONAL DAM SAFETY PROGRAM. RAMAPO LKE DAM (NJ00216), PASSAIC --ETC(U)
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PASSAIC RIVER BASIN
TRIBUTARY TO RAMAPO RIVER
BERGEN COUNTY, NEW JERSEY

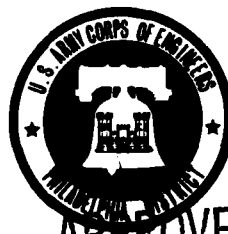
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RAMAPO LAKE DAM NJ 00216

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DTIC
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AUG 1 8 1980



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.		

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PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-N

05 AUG 1960

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Ramapo Lake Dam in Bergen County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Ramapo Lake Dam, a high hazard potential structure, is judged to be in poor overall condition. In addition, the spillway is considered seriously inadequate because a flow equivalent to 27 percent of the Probable Maximum Flood (PMF) would cause the dam to be overtopped. The seriously inadequate spillway is assessed as an UNSAFE, non-emergency condition, until more detailed studies prove otherwise or corrective measures are completed. The classification of UNSAFE applied to a dam because of a seriously inadequate spillway is not meant to indicate the same degree of emergency as would be associated with an UNSAFE classification applied for a structural deficiency. It does mean, however, that based on an initial screening, and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard of loss of life downstream from the dam. To ensure adequacy of the structure, the following actions as a minimum, are recommended.

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures and studies within six months from the date of approval of this report. Within three months of the consultant's findings remedial measures to ensure spillway adequacy should be initiated. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also during periods of unusually heavy precipitation, around the clock surveillance should be provided.

b. Within six months from the date of approval of this report, the following engineering studies and analyses should be initiated:

NAPEN-N

Honorable Brendan T. Byrne

(1) Observation wells or piezometers should be installed in the embankment to determine the location of the phreatic surface and the paths of the seepage observed.

(2) The flow of seepage should be monitored monthly to determine its volume and whether it presents a problem to the safety of the dam.

(3) Provide an additional low-level outlet of sufficient size to decrease the time to draw down the reservoir.

c. The following remedial measures should be completed within twelve months from the date of approval of this report:

(1) Remove the trees from the downstream side of the embankment and the discharge channel down to the embankment level.

(2) Realign horizontally and vertically the concrete curbing along the upstream face. Replace the curbing in the missing area.

(3) Conduct a complete topographic survey of the dam and surrounding area, in order to develop a detailed plan and several cross-sections of the dam to form a coherent as-built set.

(4) Replace both low-level outlet valves.

(5) Fill in and regrade areas of erosion along the upstream face.

(6) Remove all vegetation and trees from downstream toe area and make a thorough inspection of the area.

d. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Maguire of the Seventh District. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

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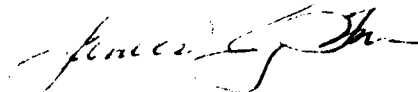
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Honorable Brendan T. Byrne

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Inspection Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,



JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Copies furnished:
Mr. Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief
Bureau of Flood Plain Regulation
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

RAMAPO LAKE DAM (NJ00216)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 13 November and 4 December 1979 by Harris-ECI Associates, Inc., under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Ramapo Lake Dam, a high hazard potential structure, is judged to be in poor overall condition. In addition, the spillway is considered seriously inadequate because a flow equivalent to 27 percent of the Probable Maximum Flood (PMF) would cause the dam to be overtopped. The seriously inadequate spillway is assessed as an UNSAFE, non-emergency condition, until more detailed studies prove otherwise or corrective measures are completed. The classification of UNSAFE applied to a dam because of a seriously inadequate spillway is not meant to indicate the same degree of emergency as would be associated with an UNSAFE classification applied for a structural deficiency. It does mean, however, that based on an initial screening, and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard of loss of life downstream from the dam. To ensure adequacy of the structure, the following actions as a minimum, are recommended.

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures and studies within six months from the date of approval of this report. Within three months of the consultant's findings remedial measures to ensure spillway adequacy should be initiated. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also during periods of unusually heavy precipitation, around the clock surveillance should be provided.

b. Within six months from the date of approval of this report, the following engineering studies and analyses should be initiated:

(1) Observation wells or piezometers should be installed in the embankment to determine the location of the phreatic surface and the paths of the seepage observed.

(2) The flow of seepage should be monitored monthly to determine its volume and whether it presents a problem to the safety of the dam.

(3) Provide an additional low-level outlet of sufficient size to decrease the time to draw down the reservoir.

c. The following remedial measures should be completed within twelve months from the date of approval of this report:

(1) Remove the trees from the downstream side of the embankment and the discharge channel down to the embankment level.

(2) Realign horizontally and vertically the concrete curbing along the upstream face. Replace the curbing in the missing area.

(3) Conduct a complete topographic survey of the dam and surrounding area, in order to develop a detailed plan and several cross-sections of the dam to form a coherent as-built set.

(4) Replace both low-level outlet valves.

(5) Fill in and regrade areas of erosion along the upstream face.

(6) Remove all vegetation and trees from downstream toe area and make a thorough inspection of the area.

d. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

APPROVED:

James G. Ton
JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE:

2 July 1982



DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE-2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-N

22 MAY 1960

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

Dear Governor Byrne:

This is in reference to our ongoing National Program for Inspection of Non-Federal Dams within the State of New Jersey. Ramapo Lake Dam (Federal I.D. No. NJ00216), a high hazard potential structure, has recently been inspected. The dam is owned by the Division of Parks and Forestry, and is located on a tributary of the Ramapo River in the Borough of Oakland.

Using Corps of Engineers screening criteria, it has been determined that the dam's five spillways are seriously inadequate because a flow equivalent to 26 percent of the Probable Maximum Flood would cause the dam to be overtopped. The seriously inadequate spillways are assessed as UNSAFE, non-emergency condition, until more detailed studies prove otherwise, or corrective measures are completed. The classification of UNSAFE applied to a dam because of a seriously inadequate spillway is not meant to indicate the same degree of emergency as would be associated with an UNSAFE classification applied for a structural deficiency. It does mean, however, that based on an initial screening and preliminary computations, there appears to be a serious deficiency in the spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam could take place, significantly increasing the hazard potential to loss of life downstream from the dam. As a result of this UNSAFE determination, it is recommended that the following measures be undertaken within 30 days of the date of this letter:

a. Initiate a study to more accurately determine the spillway adequacy by using more detailed and sophisticated hydrologic and hydraulic analyses, and to recommend any remedial measures required to prevent overtopping of the dam.

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Honorable Brendan T. Byrne

b. In the interim, a detailed emergency operation plan and downstream warning system should be promptly developed. Also, around the clock surveillance should be provided during periods of unusually heavy precipitation.

A final report on this Phase I inspection will be forwarded to you within two months.

Sincerely,



JAMES G. TON
Colonel, Corps of Engineers
District Engineer

Copies Furnished:

Mr. Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief
Bureau of Flood Plain Regulation
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

UNSAFE DAM

NATIONAL PROGRAM OF INSPECTION OF DAMS

- a. NAME: Ramapo Lake Dam b. ID NO.: NJ00216 c. LOCATION State: New Jersey, County: Bergen.
- d. HEIGHT: 8 feet e. MAXIMUM IMPOUNDMENT CAPACITY: 540 ac. ft. River or Stream: Tributary of Ramapo River.
- f. TYPE: Earthfill Masonry. g. OWNER: Division of Parks and Forestry. Nearest D/S City or Town: Borough of Oakland.
- h. DATE GOVERNOR NOTIFIED OF UNSAFE CONDITIONS: i. CONDITION OF DAM RESULTING IN UNSAFE ASSESSMENT: Preliminary report calculations indicate 26% of the PMF would overtop the dam.
- l. URGENCY CATEGORY: HIGH HAZARD, UNSAFE, Non-Emergency.
- m. EMERGENCY ACTIONS TAKEN: j. DESCRIPTION OF DANGER INVOLVED: Overtopping and failure of the dam would significantly increase hazard potential to loss of life and property downstream of dam.
- n. REMEDIAL ACTIONS TAKEN: k. RECOMMENDATIONS GIVEN TO GOVERNOR: Within 30 days of the date of the District Engineer's letter the owner should do the following:
a. Engage the services of a qualified professional consultant to more accurately determine the spillway adequacy by using more detailed and sophisticated hydrologic and hydraulic analyses, and to recommend any remedial measures required to prevent overtopping of the dam.
b. In the interim, a detailed emergency operation plan and downstream warning system should be developed. Also, around-the-clock surveillance should be provided during periods of unusually heavy precipitation.
- o. REMARKS: Final report, to be issued within six weeks, will have WHITE cover.

T.B. HEVERIN, Coordinator
Dam Inspection Program
U.S.A.E.D., Philadelphia

PASSAIC RIVER BASIN
TRIBUTARY TO RAMAPO RIVER, BERGEN COUNTY
NEW JERSEY

RAMAPO LAKE DAM

NJ00216

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA 19106

MARCH 1980

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name: Ramapo Lake Dam, I.D. NJ 00216
State Located: New Jersey
County Located: Bergen County
Stream: Tributary to Ramapo River
River Basin: Passaic River
Date of Inspection: November 13 and December 4, 1979

Assessment of General Conditions

Ramapo Lake Dam is an earthfill masonry dam containing five-concrete box spillways spaced, about equally, throughout the dam. The overall condition of the dam is poor. The concrete curbing along the upstream face is misaligned both horizontally and vertically and is tilting towards the lake. Minor seepage was occurring at six different locations along the downstream face. The downstream channel is well defined. The operation of the low-level outlets was not demonstrated since the hand wheel operators were missing. The hazard potential is rated as "high".

The adequacy of Ramapo Lake Dam is considered questionable in view of its lack of spillway capacity to pass the SDF (1/2 PMF) without overtopping the dam. The spillway is capable of passing a flood equal to 26 percent of the PMF (52 percent of one half PMF), and is assessed as "seriously inadequate".

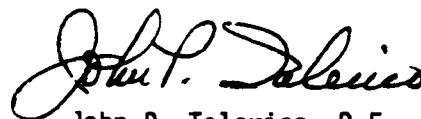
At present, the engineering data available is not sufficient to make a definitive statement on the stability of the dam. The following actions, therefore, are recommended along with a timetable for their completion. All recommended actions should be conducted under the supervision of an Engineer who is experienced in the design, construction and inspection of dams.

1. Carry out a more precise hydrologic and hydraulic analysis of the dam within twelve months, to determine the need and type of mitigating measures necessary. If required, conduct a study of the means of increasing spillway discharge capacity and develop alternative schemes for construction. This should include the installation of headwater and tailwater gages. The ability of the dam to withstand overtopping should also be studied.
2. Observation wells or piezometers should be installed in the embankment to determine the location of the phreatic surface and the paths of the seepage observed. This should be done within six months.

3. The flow of seepage should be monitored monthly to determine its volume and whether it presents a problem to the safety of the dam.
4. Conduct a complete topographic survey of the dam and surrounding area, in order to develop a detailed plan and several cross-sections of the dam to form a coherent as-built set within twelve months.
5. Provide an additional low-level outlet of sufficient size to decrease the time to draw down the reservoir. This should be completed within six months.
6. Remove the trees from the downstream side of the embankment and the discharge channel down to the embankment level. This program should be started within twelve months.
7. Realign horizontally and vertically the concrete curbing along the upstream face. Replace the curbing in the missing area. This work should be completed within twelve months.
8. Replace both low-level outlet valves within twelve months.
9. Fill in and regrade areas of erosion along the upstream face within twelve months.
10. Remove all vegetation and trees from downstream toe area and make a thorough inspection of the area. This program should be completed within twelve months.
11. The owner should develop an emergency action plan (if one is not already available) outlining actions to be taken by the operator to minimize downstream effects of an emergency and establish a flood warning system for the downstream communities within three months.

Furthermore, while of a less urgent nature, the following additional action is recommended and should be carried out within a reasonable period of time.

1. The owner should develop within one (1) year after formal approval of the report, written operating procedures and a periodic maintenance plan to insure the safety of the dam.

A handwritten signature in cursive script, reading "John P. Talerico".

John P. Talerico, P.E.
HARRIS-ECI ASSOCIATES



Photo taken on December 4, 1979

R A M A P O L A K E D A M

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the office of the Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

RAMAPO LAKE DAM, I.D. NJ 00216

SECTION 1

1. PROJECT INFORMATION

1.1 General

a. Authority

The National Dam Inspection Act (Public Law 92-367, 1972) provides for the National Inventory and Inspection Program by the U.S. Army Corps of Engineers. This inspection was made in accordance with this authority under Contract C-FDM No. 35 with the State of New Jersey who, in turn, is contracted to the Philadelphia District of the Corps of Engineers, and was carried out by the engineering firm of Harris-ECI Associates, Woodbridge, New Jersey.

b. Purpose of Inspection

The visual inspection of Ramapo Lake Dam was made on November 13 and December 4, 1979. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

The report summarizes available pertinent data relating to the project; presents a summary of visual observations made during the field inspection; presents an evaluation of hydrologic and hydraulic conditions at the site; presents an evaluation as to the structural adequacy of the various project features; and assesses the general condition of the dam with respect to safety.

1.2 Description of Project

a. Description of Dam and Appurtenances

Ramapo Lake Dam is an earthfill masonry dam approximately 300-foot long and 8-foot high. Five concrete spillways, each consisting of two one-foot high by 5-foot wide box culverts under the crest, control the flow through the embankment. The top of the spillways varies from 0.3 to 1.1 feet below the crest of the dam.

The embankment has a top width of 17.4 feet and is contained by a vertical cobblestone wall upstream and a cobblestone wall with a side slope of 1H:1V downstream. There is a dirt roadway across the top of the dam with vertically placed concrete slabs, approximately 1.2-foot high, acting as roadway curbing along both sides of the dam's crest. The length of the dam with the curbing is approximately 247 feet.

The low-level outlet consists of two 6-inch cast iron pipes through the dam approximately 53.5 feet from the right end of the dam. The flow through the pipes is controlled by manually operated gate valves located in the downstream side of the embankment. The inlet end of the pipes are located in the upstream face of the embankment. The outlets discharge directly into the discharge channel.

The flow from the spillways form the downstream channel approximately 25 feet from the dam. The channel is 10-foot wide with 3-foot high banks. The channel continues downstream until it crosses under Skyline Drive approximately 3000 feet from the dam. From there it flows into the Ramapo River approximately 1300 feet from Skyline Drive.

No borings were uncovered during the report preparation phase.

A generalized description of soil conditions is contained in Report No. 4, Bergen and Hudson Counties, Engineering Soil Survey of New Jersey, by Rutgers University. The report describes the dam area as Gneissic bedrock erratically covered with a variable, but thin, mantle of unconsolidated glacial materials.

Geologic overlay sheet 23 describes the rock as Horblende Granite and Gneiss. Noteworthy on this overlay is that a fault passes through the lake about 1/8 of a mile to its north.

b. Location

Ramapo Lake Dam is located in the Ramapo Mountains State Forest. It is a tributary to the Ramapo River in the Borough of Oakland, Bergen County, New Jersey. It is accessible by way of Skyline Drive.

c. Size Classification

According to the "Recommended Guidelines for Safety Inspection of Dams" by the U.S. Department of the Army, Office of the Chief of Engineers, the dam is classified in the dam size category as being "small", since its storage volume of 540 acre-feet is less than 1,000 acre-feet. The dam is also classified as small because its height of 8 feet is less than 40 feet. The overall size classification of Ramapo Lake Dam is small.

d. Hazard Classification

A hazard potential classification of "high" has been assigned to the dam on the basis that a hypothetical failure would result in excessive damage to the many houses and the road downstream of the dam. Because the road is heavily traveled and there are several habitable buildings within the flood path, the possibility exists of the loss of more than a few lives in the event of dam failure.

e. Ownership

Ramapo Lake Dam is owned by:

State of New Jersey
Department of Environmental Protection
Division of Parks and Forestry
Trenton, New Jersey 08625

Attention: Mr. John Nichols
Park Supervisor
(201) 337-0960

f. Purpose

Ramapo Lake Dam is presently used for recreational purposes only.

g. Design and Construction History

No information is available on the original design of the dam which was built prior to 1904.

h. Normal Operating Procedures

The discharge from the lake is unregulated and is allowed to naturally balance the inflow into the lake. The low-level outlets are used to lower the lake level as required.

1.3 Pertinent Data

a. Drainage Area 0.89 sq.mi.

b. Discharge at Dam Site

Ungated spillway capacity at elevation of top of dam: 245 cfs (558.8 NGVD)

Total spillway capacity at maximum pool elevation (SDF): 564 cfs (560.01 NGVD)

c. Elevation (Feet above NGVD)

Top of dam: 558.8 (Top of embankment)
560.0 (Top of curb), 247 ft. long)

Maximum pool design surcharge (SDF): 559.64

Recreation pool: 557.1

Spillway crest: 556.7

Streambed at centerline of dam: 547.0 (estimated)

Maximum tailwater: 549.0 (estimated)

d. Reservoir

Length of maximum pool: 4,800 ft. (estimated)

Length of recreation pool: 4,700 ft. (estimated)

e. Storage (acre-feet)

Recreation pool: 240 (estimated)

Spillway crest: 206

Top of dam: 406

Maximum pool (SDF): 540

f. Reservoir Surface (acres)

Top of dam: 98.3 (estimated)

Maximum pool (SDF): 117.0 (estimated)

Recreation pool: 90

Spillway crest: 81.2 (estimated)

g. Dam

Type:	Earthfill Masonry dam with 5 concrete box spillways
Length:	300 ft. (effective)
Height:	8 ft. (structural); 13 ft. (hydraulic)
Top width:	17.4 ft.
Side slopes - Upstream:	Vertical
- Downstream:	1H:1V
Zoning:	Unknown
Impervious core:	Unknown
Cutoff:	Unknown
Grout curtain:	None

h. Diversion and Regulating Tunnel

N/A

i. Spillway

Type:	5 concrete box culverts
Length of weir:	10 spillways at 5 ft. each = 50 ft.
Crest elevation:	556.7 MSL
Gates:	None
U/S Channel:	Ramapo Lake
D/S Channel:	Natural channel with 10' bottom width and grass overgrown on banks.

j. Regulating Outlets

Low level outlet:	2 - 6 inch CIP with gate valves
Controls:	Manually controlled
Emergency gate:	None
Outlet:	552.9 NGVD 555.6 NGVD

SECTION 2

2. ENGINEERING DATA

2.1 Design

There are no drawings or design computations for the dam available. No data from soil borings, soil tests, or other geotechnical data is available. No cross-sections suitable for assessing the stability are available.

2.2 Construction

Data is not available concerning the construction of the dam.

2.3 Operation

Formal operation records are not kept for the dam and reservoir. The lake is allowed to operate naturally without regulation.

2.4 Evaluation

a. Availability

The availability of engineering data is very poor.

b. Adequacy

The engineering data obtained in the field was adequate to perform hydrologic and hydraulic computations. The data was insufficient to perform a stability analysis, but preliminary evaluation could be made based on visual observations.

c. Validity

Since no existing engineering data exists, the validity of that data could not be compared to the data obtained in the field.

SECTION 3

3. VISUAL INSPECTION

3.1 Findings

a. General

The usual inspection of Ramapo Lake Dam revealed the dam to be in poor condition and in need of repairs.

b. Dam

The earth embankment appears to be sound. No misalignment of the horizontal or vertical plane of the embankment was noticed, however, the vertical and horizontal alignment of the upstream concrete curbing is irregular with the curbing tilting towards the lake. Also, a section of the curbing has fallen into the lake at the left end of the dam. Seepage was occurring at six different locations. The locations were 53, 92, 121, 172, 186 and 217 feet from the right end of the dam. The amount of seepage was minor and was running clear. There is minor erosion along the upstream face of the embankment at the left end where the concrete curbing is missing. Also, there are voids between the curbing and the embankment crest along the upstream side. Small trees are growing along the downstream embankment slope. Trees and vegetation growing along the downstream toe of the embankment prevented a proper inspection of the toe area.

c. Appurtenant Structures

1. Spillways

The five concrete spillways just below the crest and through the embankment were in good condition. No spalling or cracking of the concrete could be observed. The steel beams supporting the concrete curbing are in good condition. Small trees are growing out of the discharge channels in two of the spillways.

2. Outlet Works

Two 6-inch cast iron pipes exit at the downstream side of the embankment just to the right of the second spillway, at the right end of the dam. The inlet ends of the pipes were under water and could not be inspected. The valves to operate the outlets are at the discharge end of the pipes. The upper valve rests on a masonry support and has a vertical crack along its entire height. Both valves as well as the two outlets were severely weathered and rusty. The hand wheel operators were missing, therefore, the operation of the valves was not demonstrated.

d. Reservoir Area

The side slopes of the reservoir are steep and are heavily wooded. The lake appeared clean with no indication of surface growth.

e. Downstream Channel

The downstream channel is in fair condition. It is thick with trees and vegetation. The banks are steep and are about 3 feet in height. The channel winds down the mountain until it crosses under Skyline Drive approximately 3000 feet away from the dam. It then flows into the Ramapo River approximately 1300 feet from the Skyline Drive.

SECTION 4

4. OPERATIONAL PROCEDURES

4.1 Procedures

Ramapo Lake Dam is used to impound water for recreational activities. The level of the lake is maintained through the unregulated flow over the spillways. The lake is not lowered on a regular basis.

4.2 Maintenance of the Dam

There is no regular inspection and maintenance program for the dam and appurtenant structures. The NJ-DEP, Division of Parks and Forestry, is responsible for the maintenance of the dam.

4.3 Maintenance of Operating Facilities

The low-level outlet operating facilities consist of the two manually operated 6-inch gate valves. At the time of inspection, operation of the valves were not demonstrated because the hand wheel operators were missing.

4.4 Evaluation

The present operational and maintenance procedures are fair with the dam and spillway being maintained in a serviceable condition.

SECTION 5

5. HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design

The drainage area above Ramapo Lake Dam is approximately 0.89 square miles. A drainage map of the watershed of Ramapo Lake Dam is presented on plate 1, Appendix D.

The topography within the basin is generally moderately sloped. Elevations range from approximately 1,000 feet above NGVD at the north end of the watershed to about 557 feet at the dam site. Land use patterns within the watershed are mostly woodland.

The evaluation of the hydraulic and hydrologic features of Ramapo Lake was based on criteria set forth in the Corps guidelines and additional guidance provided by the Philadelphia District, Corps of Engineers. The SDF for Ramapo Lake Dam falls in a range of 1/2 PMF to PMF. In this case the low end of the range, 1/2 PMF, is chosen since the factors used to select size and hazard classification are on the low-side of their respective ranges.

The probable maximum flood (PMF) was calculated from the probable maximum precipitation using Hydrometeorological Report No. 33 with standard reduction factors. Due to the small drainage area, the SCS triangular hydrograph transformed to a curvilinear hydrograph was adopted for developing the unit hydrograph, with the aid of the HEC1-DB Flood Hydrograph, Computer program.

Initial and constant infiltration loss rates were applied to the Probable Maximum Precipitation to obtain rainfall excesses. The rainfall excesses were applied to the unit hydrograph to obtain the PMF and various ratios of PMF utilizing program HEC1-DB.

The SDF peak outflow calculated for Ramapo Lake Dam is 564 cfs. This value is derived from the 1/2 PMF and results in overtopping the dam assuming that the lake was originally at the spillway crest elevation.

The stage-outflow relation for the spillway was determined from the geometry of the spillway and dam, utilizing HEC1-DB program field notes and sketches. The reservoir stage capacity was based on the U.S.G.G. quadrangle topographic maps.

The reservoir stage-storage capacity was computed directly by the conic method, utilizing the HEC1-DB program. The reservoir surface areas at various elevations were measured by planimeter from a U.S.G.S. Quadrangle topographic map. Reservoir storage capacity included surcharge levels exceeding the top of the dam, and the spillway rating curve was based on the assumption that the dam remains intact during routing.

A breach analysis indicates that the stage of the stream where it crosses Skyline Drive is 3.4 feet higher, due to dam failure from overtopping at 30 percent PMF than it would be without failure at 30 percent PMF. This is likely to jeopardize the well traveled road and approximately 10 houses downstream of the road significantly more than without failure. As indicated in Section 5.1.d., the discharge facility is thus rated "seriously inadequate".

Drawdown calculations indicate that to empty the lake to an elevation of 552.9' NGVD through the two low-level outlets would take 114 days, with no inflow. Consequently an increased low-level outlet capacity should be provided.

b. Experience Data

No records of reservoir stage or spillway discharge are maintained for this site.

c. Visual Observation

The downstream channel is well defined with steep banks. Thick vegetation and trees line the banks. The channel winds down the mountain until it crosses Skyline Drive approximately 3,000 feet from the dam. After crossing Skyline Drive, the channel flows into the Ramapo River approximately 1,300 feet from the road. There is one house on the left bank at Skyline Drive and approximately 10 houses between the road and the river.

The slopes of the reservoir are steep and wooded and do not exhibit signs of instability. The drainage area is wooded and moderately sloped.

d. Overtopping Potential

A storm of magnitude equivalent to the SDF would cause overtopping of the dam to a height of 1.21 feet. Computations indicate that the dam can pass approximately 26% of the PMF (52 percent of the 1/2 PMF) without overtopping the dam crest. Since one half the PMF is the minimum Spillway Design Flood (1/2 PMF) for this dam, according to the Recommended Guidelines for Safety Inspection of Dams by the Corps of Engineers, the spillway capacity of the Ramapo Lake Dam is assessed as "seriously inadequate".

SECTION 6

6. STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

The concrete curbing along the upstream crest of the dam is misaligned vertically and horizontally and is tilting towards the lake. The cause of this movement is unknown. Trees growing out of the downstream embankment and spillway discharge channels could pose a threat to stability. The spillways are in good condition. Seepage was occurring at six different locations. The locations were at points 53, 92, 121, 172, 186 and 217 feet from the right end of the dam. The seepage, at all six locations, was near the toe of the dam. The seepage has not been monitored and no information was uncovered concerning their duration or flow rates.

b. Design and Construction Data

No design computations relating to stability were uncovered during the report preparation phase. No embankment or foundation soil parameters are available for carrying out a conventional stability analysis on the embankment.

c. Operating Records

No operating records are available relating to the stability of the dam.

d. Post-Construction Changes

There are no known post-construction changes.

e. Static Stability

A static stability analysis was not performed for Ramapo Lake Dam because the lack of data on which to base assumptions of material properties inside embankment zones might produce misleading results, but based on the findings of the visual inspection, the preliminary assessment of static stability is that it is satisfactory.

f. Seismic Stability

The dam is located in Seismic Zone 1, as defined in Recommended Guidelines for Safety Inspection of Dams, prepared by the Corps of Engineers. In general, projects located in Seismic Zones 0, 1, and 2 may be assumed to present no hazard from earthquake, provided the static stability conditions are satisfactory and conventional safety margins exist and based on the findings of the visual inspection, the preliminary assessment of the static and seismic stabilities is that they are satisfactory.

SECTION 7

7. ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety

The dam has been inspected visually and a review has been made of the available engineering data. This assessment is subject to the limitations inherent in the visual inspection procedures stipulated by the Corps of Engineers for a Phase I report.

The safety of Ramapo Lake Dam is in question because the dam does not have adequate spillway capacity to pass the SDF (1/2 PMF) without overtopping. Overtopping of the dam carries with it the danger of possible progressive failure of the dam. The present spillway capacity of the dam is approximately 26 percent of the PMF (52 percent of the 1/2 PMF).

No definite statement pertaining to the safety of the embankment can be made without acquisition of embankment material engineering properties and determination of phreatic levels in the downstream part of the embankment.

b. Adequacy of Information

The information uncovered was adequate to perform hydrologic and hydraulic computations. The data was insufficient to perform even an approximate computation of the stability of the dam. A preliminary assessment of the dam could be made by visual observation only.

c. Urgency

The remedial measures and recommended actions along with a timetable for their completion are detailed below. All recommended action should be conducted under the supervision of an engineer who is experienced in the design, construction and inspection of dams.

7.2 Remedial Measures

a. Alternatives for Increasing Spillway Capacity

Alternatives for increasing spillway capacity are as follows:

1. Increase the embankment height of the dam thus permitting a higher discharge to pass over the

spillway and reducing the possibility of overtopping.

2. Lower the spillway crest elevation.
3. Increase the effective spillway crest length.
4. A combination of any of the above alternatives.

b. Recommendations

1. Carry out a more precise hydrologic and hydraulic analysis of the dam within twelve months, to determine the need and type of mitigating measures necessary. If required, conduct a study of the means of increasing spillway discharge capacity and develop alternative schemes for construction. This should include the installation of headwater and tailwater gages. The ability of the dam to withstand overtopping should also be studied.
2. Observation wells or piezometers should be installed in the embankment to determine the location of the phreatic surface and the paths of the seepage observed. This should be done within six months.
3. The flow of seepage should be monitored monthly to determine its volume and whether it presents a problem to the safety of the dam.
4. Conduct a complete topographic survey of the dam and surrounding area, in order to develop a detailed plan and several cross-sections of the dam to form a coherent as-built set within twelve months.
5. Provide an additional low-level outlet of sufficient size to decrease the time to draw down the reservoir. This should be completed within six months.
6. Remove the trees from the downstream side of the embankment and the discharge channel down to the embankment level. This program should be started within twelve months.
7. Realign horizontally and vertically the concrete curbing along the upstream face. Replace the curbing in the missing area. This work should be completed within twelve months.

8. Replace both low-level outlet valves within twelve months.
9. Fill in and regrade areas of erosion along the upstream face within twelve months.
10. Remove all vegetation and trees from downstream toe area and make a thorough inspection of the area. This program should be completed within twelve months.

The following additional actions are recommended:

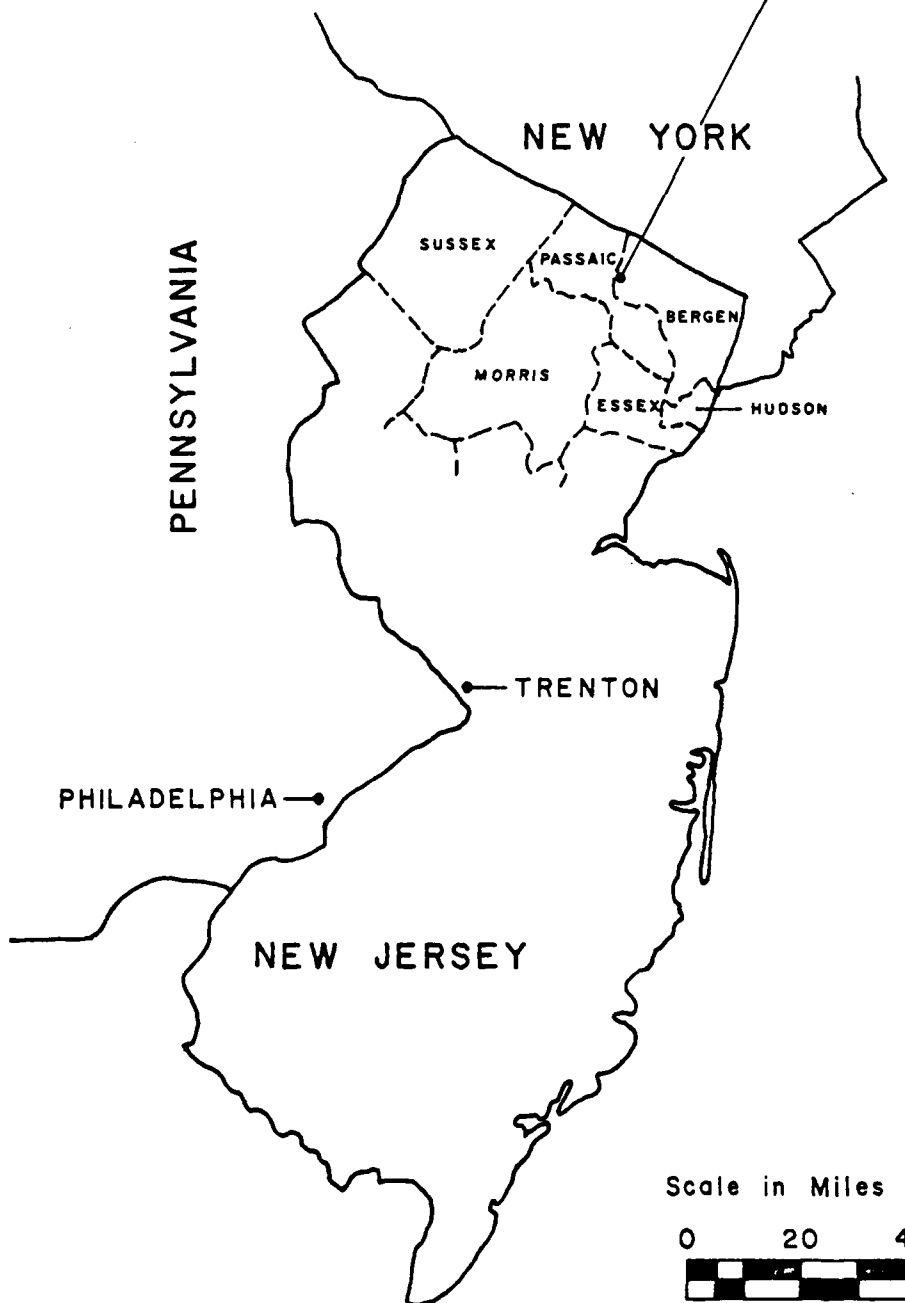
1. The owner should develop an emergency action plan (if one is not already available) outlining actions to be taken by the operator to minimize downstream effects of an emergency and establish a flood warning system for the downstream communities within three months.

c. O & M Procedures

The owner should develop, within one (1) year after formal approval of the report, written operating procedures and a periodic maintenance plan to insure the safety of the dam.

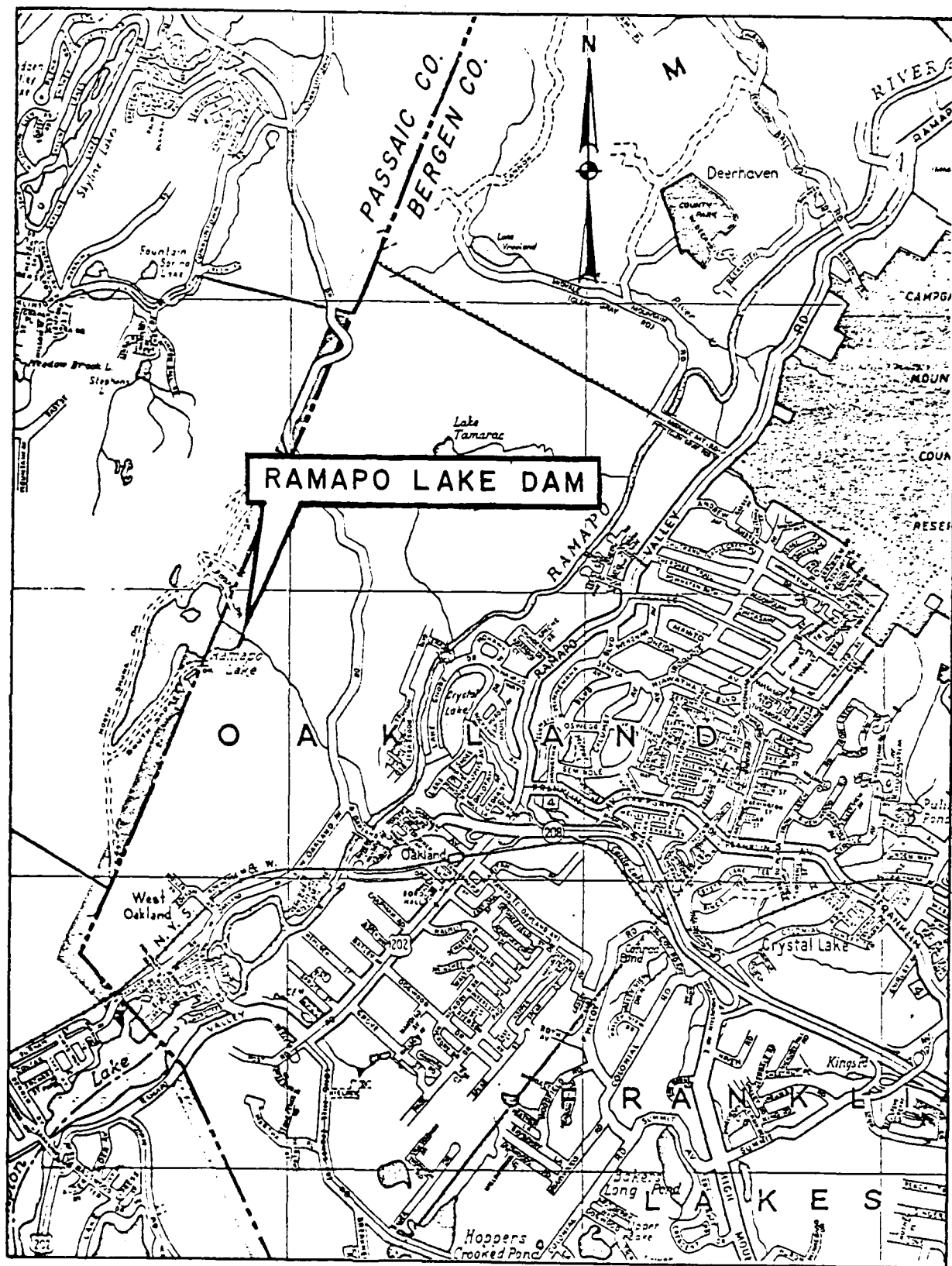
P L A T E S

RAMAPO LAKE DAM
BORO OF OAKLAND
BERGEN COUNTY, N. J.

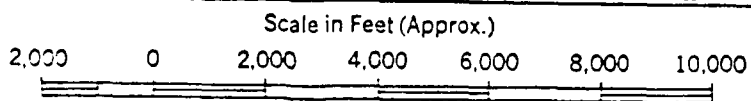


KEY MAP

PLATE I

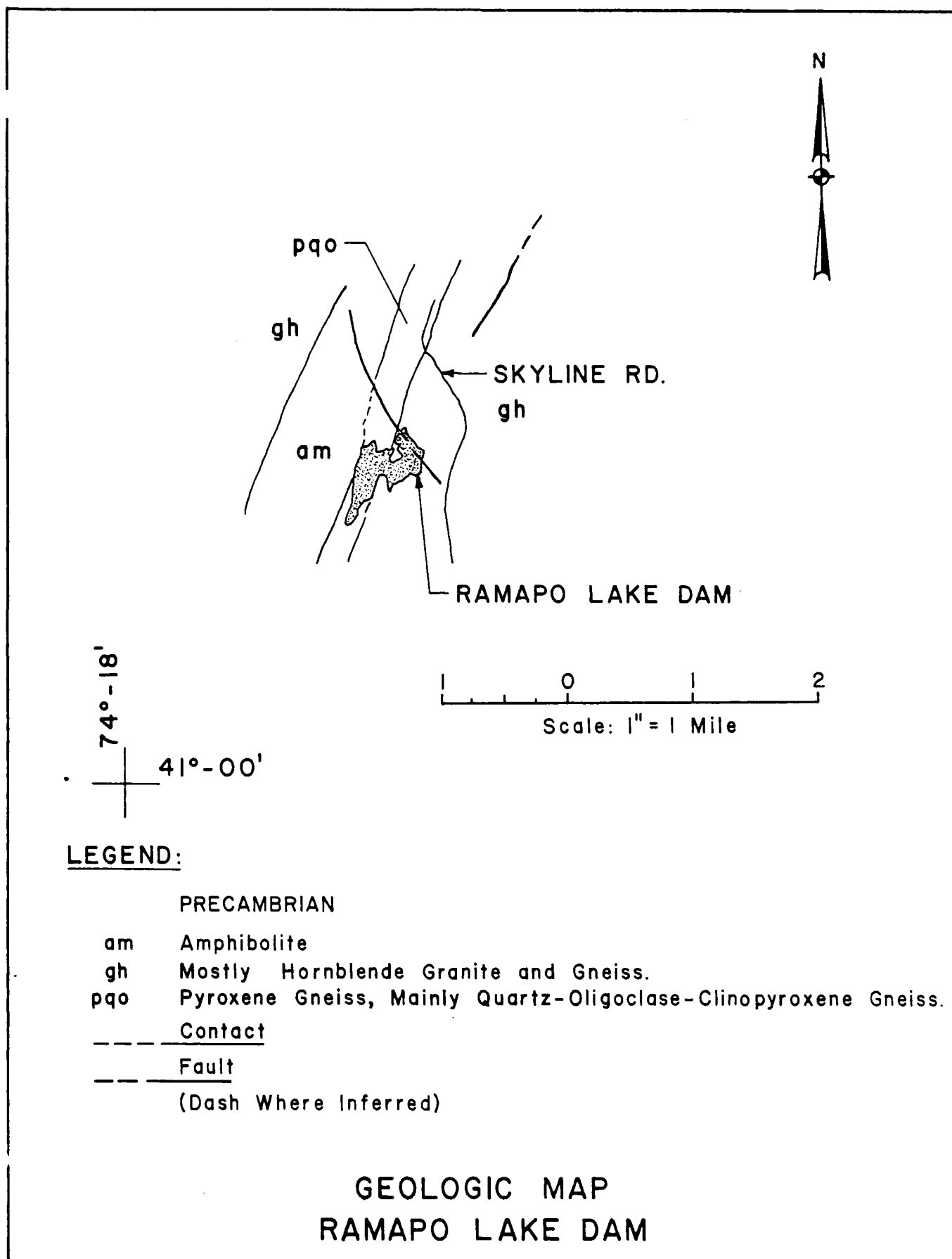


RAMAPO LAKE DAM



VICINITY MAP

PLATE 1A

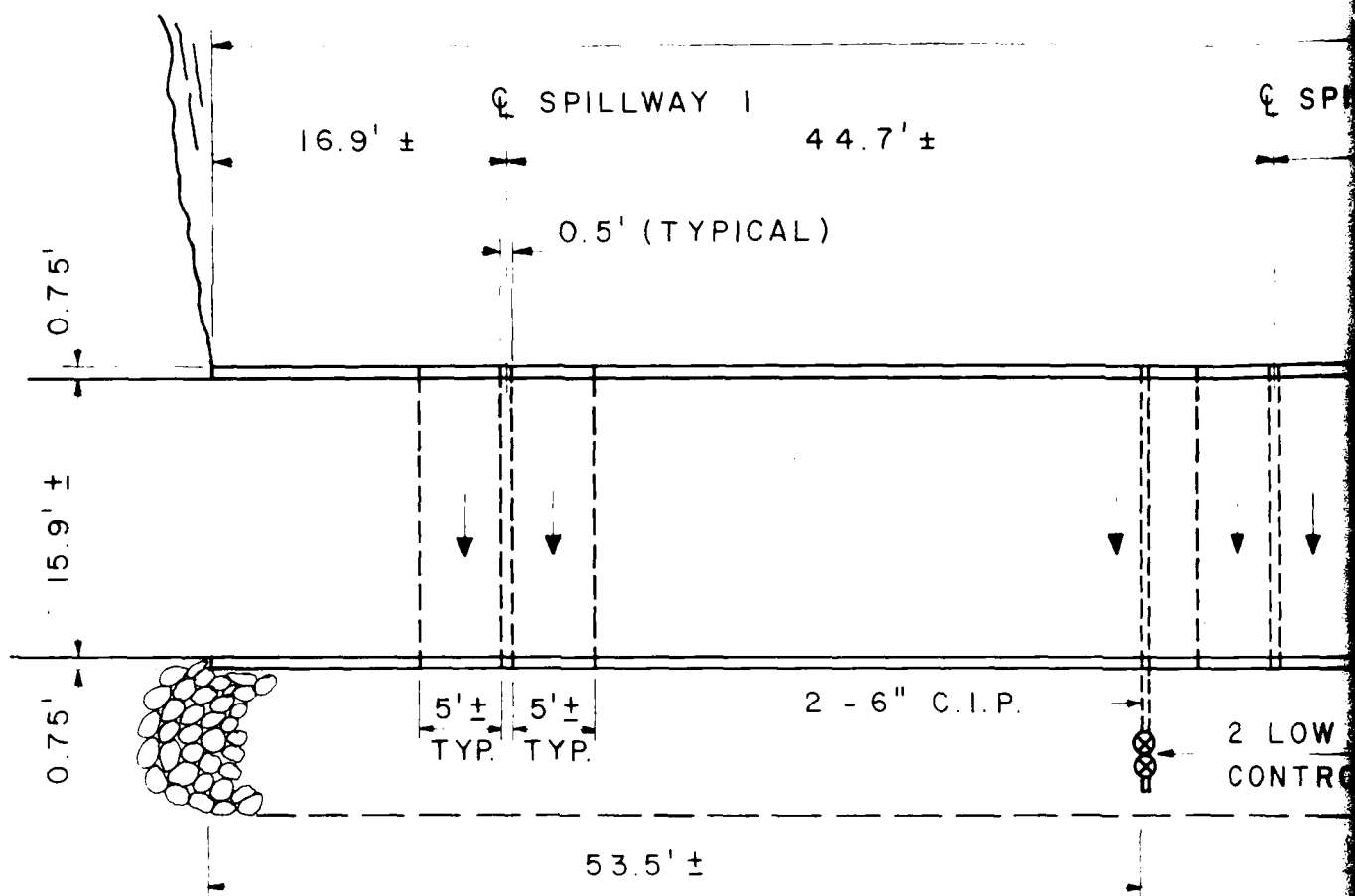


LEGEND:

PRECAMBRIAN

- am Amphibolite
- gh Mostly Hornblende Granite and Gneiss.
- pqo Pyroxene Gneiss, Mainly Quartz-Oligoclase-Clinopyroxene Gneiss.
- Contact
- Fault
- (Dash Where Inferred)

GEOLOGIC MAP RAMAPO LAKE DAM



300' ± 0

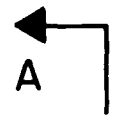
CL SPILLWAY 2

46.8' ±

CL SPILLWAY 3

46.8' ±

R A M A P O



DIRT ROAD

CONCRETE CURB

CONCRETE CURB

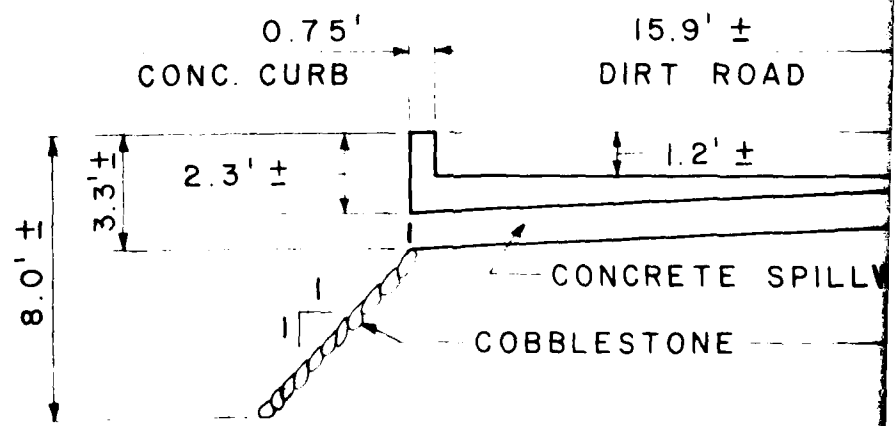
2 LOW LEVEL
CONTROL VALVES

COBBLESTONE



PLAN

SCALE: 1" = 10'



SECTION A-A

SCALE: 1" = 5'

DAM

SPILLWAY 4

47.2' ±

SPILLWAY 5

44.1' ±

L A K E

20.7' ±

6' ±

15.9' ±

0.75'

10'

0.75'
CONC. CURB

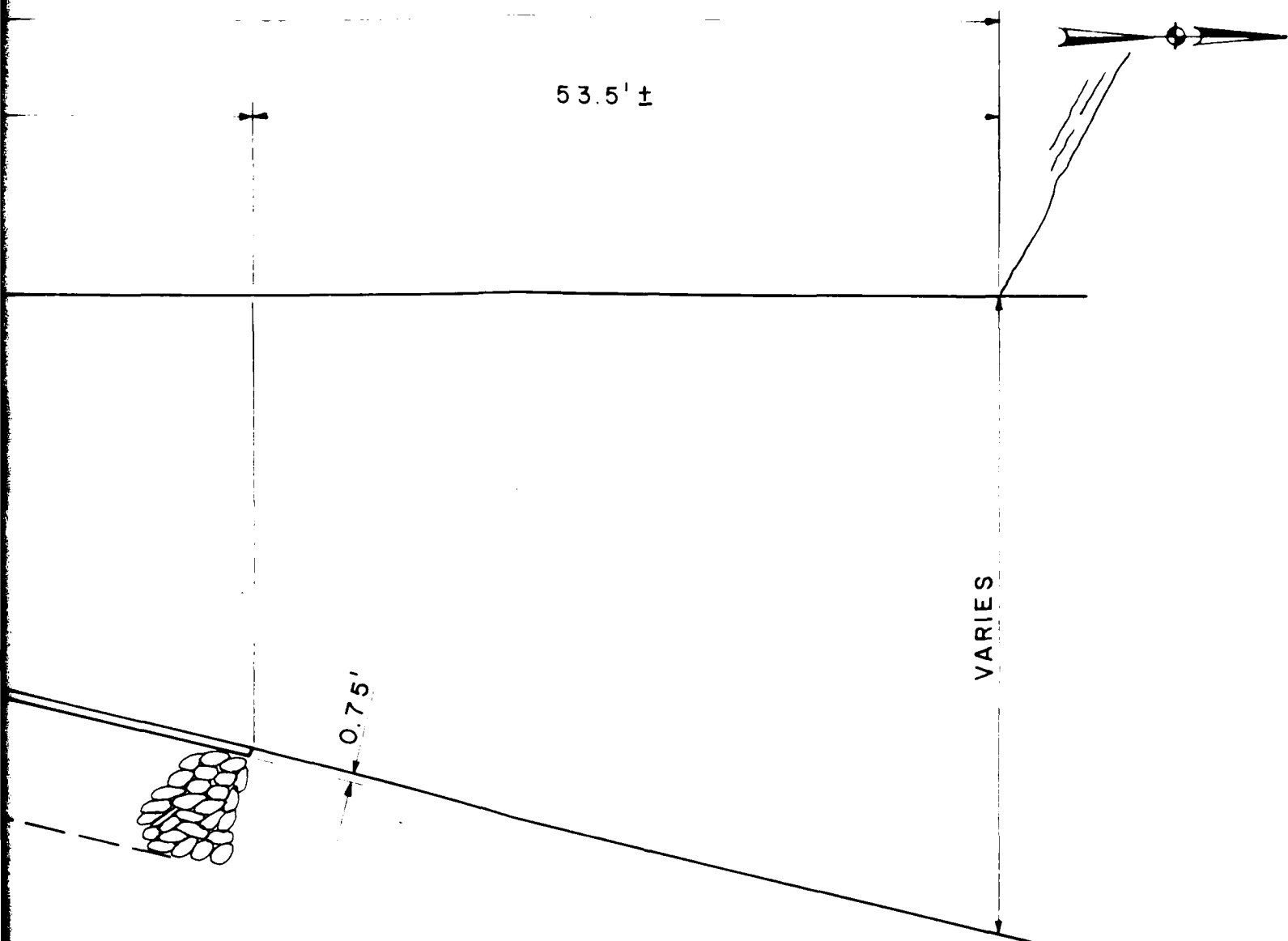
1.5' ±

2.5' ±

2.9' ±

LWAY

1)

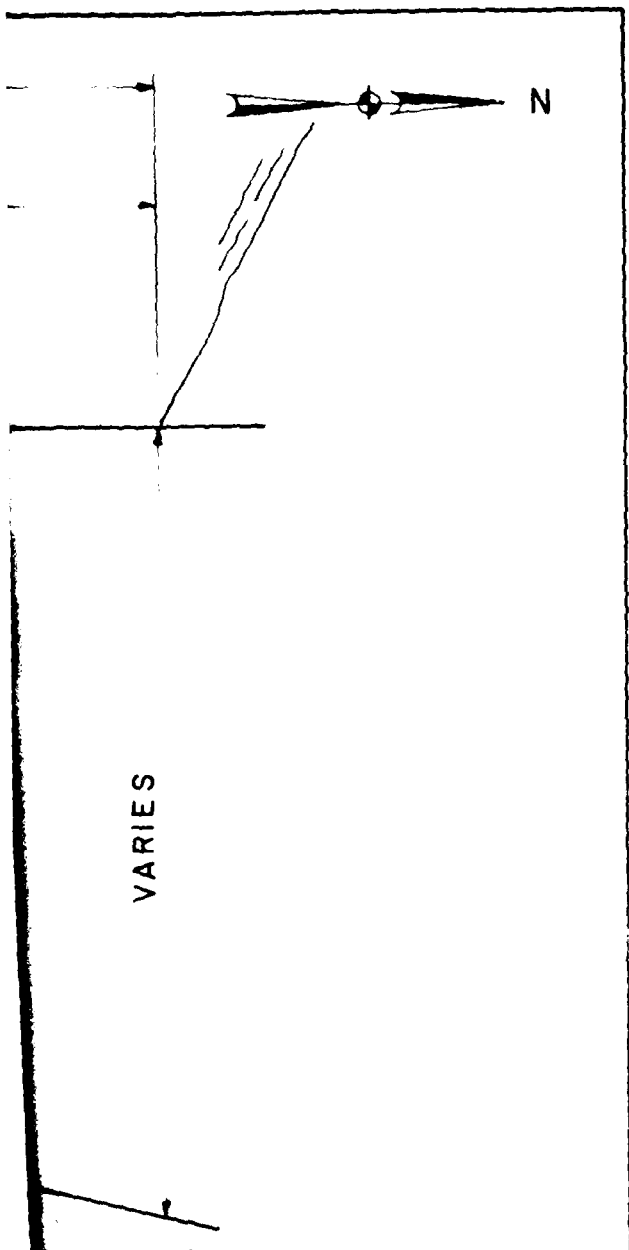


RAMAPO LAKE DAM
BORO OF OAKLAND, BERGEN COUNTY, N

SKETCHES OF PLAN AND SECTION
PREPARED FROM FIELD NOTES TAKEN
DURING INSPECTION ON NOV. 13, 1979

BY:
HARRIS - ECI ASSOCIATES
WOODBIDGE, NEW JERSEY

SCALE: AS SHOWN
DATE: FEB. 1, 1981
SHEET: 1 OF 1



VARIES

PO LAKE DAM
ND, BERGEN COUNTY, N.J.

F PLAN AND SECTION
M FIELD NOTES TAKEN
TION ON NOV. 13, 1979

TES
RSEY

SCALE: AS SHOWN
DATE: FEB. 1, 1980
SHEET: 1 OF 1

APPENDIX A

CHECK LIST - VISUAL OBSERVATIONS

CHECK LIST - ENGINEERING, CONSTRUCTION
MAINTENANCE DATA

CHECK LIST
VISUAL INSPECTION
PHASE 1

Name Dam RAMAPO LAKE DAM County Bergen State New Jersey Coordinators NJ-DEP

Date(s) Inspection November 13, 1979 Weather Cloudy Temperature 48° F
December 4, 1979

Pool Elevation at Time of Inspection 556.7 NGVD Tailwater at Time of Inspection 548.0 NGVD

Inspection Personnel:

November 13, 1979:

Chuck Chin
Henry King (Recorder)
Thomas Lakovich

December 4, 1979:

Chuck Chin
James McCormick

Owner/Representative:
November 13, 1979

John Nichols - Park Supervisor
Ramapo Mountain State Forest
P.O. Box 225
Oakland, NJ 07436

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SEEPAGE OR LEAKAGE N/A		
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS N/A		
DRAINS N/A		
WATER PASSAGES N/A		
FOUNDATIONS N/A		

CONCRETE/MASONRY DAMS		REMARKS AND RECOMMENDATIONS
VISUAL EXAMINATION OF	OBSERVATIONS	
SURFACE CRACKS CONCRETE SURFACES N/A		
STRUCTURAL CRACKING N/A		
VERTICAL & HORIZONTAL ALIGNMENT N/A		
MONOLITH JOINTS N/A		
CONSTRUCTION JOINTS N/A		

VISUAL EXAMINATION OF	EMBANKMENT OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SURFACE CRACKS None noticed	UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE No visible movement or cracking at or beyond the toe was noticed; however, trees and vegetation were too thick along toe for proper inspection.	Remove vegetation from along toe of slope.
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES Erosion of embankment crest along upstream face at left end of dam and this erosion creating voids between the crest and the bottom of concrete curbing along upstream face.		Fill in voids.
VERTICAL & HORIZONTAL ALIGNMENT OF THE CREST Embankment good. Concrete curb at upstream crest was irregular in alignment and tilting towards lake. Small section of curb near left upstream end missing. Downstream curb shows good alignment.		Cause of tilting unknown. Realign and replace missing curbing.
RIPRAP FAILURES No riprap		

VISUAL EXAMINATION OF	EMBANKMENT OBSERVATIONS	REMARKS AND RECOMMENDATIONS
	Small trees were growing out of embankment face at spillways 2 and 4 and along toe of slope.	Remove the trees down to the embankment level.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM N/A		
ANY NOTICEABLE SEEPAGE	Seepage was occurring at six locations along the downstream side of the dam. The locations are 53', 92', 121', 172', 186' and 217' from dam's right end. The seepage, at all six locations, was near the toe of the dam. Seepage was not monitored but it was clear and its quantity was small.	Monitor periodically for clearness and quantity.
STAFF GAGE AND RECORDER	None.	
DRAINS	None.	

VISUAL EXAMINATION OF	OUTLET WORKS OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CRACKING & SPALLING OF CONCRETE SURFACES IN STILLING BASIN N/A - Low-level outlets discharge into spillway discharge channel.		
INTAKE STRUCTURE Low-level drain under water in lake. Not visible.		
OUTLET STRUCTURE Two 6-inch cast iron pipes, located 53.5 feet from dam's right end, discharge a few feet to right of second spillway. The pipes are approximately 1.5 feet and 4.0 feet below lake level. Valves appeared severely weathered and rusty. Upper valve has a vertical crack along its entire height. Hand wheel operators were missing.		Replace both valves.
OUTLET FACILITIES None.		
EMERGENCY GATE None.		

VISUAL EXAMINATION OF	UNGATED SPILLWAY OBSERVATIONS	REMARKS AND RECOMMENDATIONS
<p>CONCRETE WEIR</p> <p>Five spillways, almost equal distances apart, under embankment crest in good condition. Steel beams under crest extremities. H-beams along with concrete or steel panel slabs (not visible) support roadway.</p>		
<p>APPROACH CHANNEL</p> <p>Reservoir</p>		
<p>DISCHARGE CHANNEL</p> <p>Small trees were growing out of the downstream slope of the discharge channel for two of the spillways. Other channels in good condition.</p>		<p>Remove trees down to the embankment level.</p>
<p>BRIDGE AND PIERS</p> <p>None</p>		

GATED SPILLWAY	
VISUAL EXAMINATION OF	REMARKS AND RECOMMENDATIONS
CONCRETE SILL N/A	
APPROACH CHANNEL N/A	
DISCHARGE CHANNEL N/A	
BRIDGE AND PIERS N/A	
GATES & OPERATION EQUIPMENT N/A	

INSTRUMENTATION		REMARKS AND RECOMMENDATIONS
VISUAL EXAMINATION OF	OBSERVATIONS	
MONUMENTATION/SURVEYS None		
OBSERVATION WELLS None		
WEIRS None		
PIEZOMETERS None		
OTHER None		

RESERVOIR		REMARKS AND RECOMMENDATIONS
VISUAL EXAMINATION OF	OBSERVATIONS	
SLOPES Earth slopes steep and heavily wooded. No indication of slope instability.		
SEDIMENTATION None noticed.		

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
	<p>CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)</p> <p>Channel thick with vegetation and trees along bank. Channel about 10 foot wide with 3 foot steep banks. Channel winds down mountain and crosses under Skyline Drive before discharging into the Ramapo River.</p>	<p>Remove vegetation from channel.</p>
<p>SLOPES</p> <p>Steep</p>		
<p>APPROXIMATE NUMBER OF HOMES AND POPULATION</p> <p>One house on east side of Skyline Drive. Approximately 10 houses where channel discharges into Ramapo River.</p>		

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	None available.
REGIONAL VICINITY MAP	Available - Passaic County Map & U.S.G.S. Quadrangle Sheet for Wanaque, N.J.
CONSTRUCTION HISTORY	None available.
TYPICAL SECTIONS OF DAM	None available.
HYDROLOGIC/HYDRAULIC DATA	None available.
OUTLETS - PLAN	None available.
- DETAILS	None available.
- CONSTRAINTS	None
- DISCHARGE RATINGS	Not available
RAINFALL / RESERVOIR RECORDS	Not available.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

ITEM	REMARKS
DESIGN REPORTS	None available.
GEOLOGY REPORTS	Available U.S.G. S. Geologic overlay sheet for Bergen and Passaic Counties. Engineering Soil Survey of New Jersey, Report No. 4-Bergen and Hudson Counties, by Rutgers University.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None available.
POST-CONSTRUCTION SURVEYS OF DAM	Unknown.
BORROW SOURCES	Unknown.
SPILLWAY PLAN - SECTIONS DETAILS	None available.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

ITEM	REMARKS
OPERATING EQUIPMENT PLANS AND DETAILS	None available.
MONITORING SYSTEMS	None available.
MODIFICATIONS	Unknown.
HIGH POOL RECORDS	Not kept.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Unknown.
PRIOR ACCIDENTS OF FAILURE OF DAM - DESCRIPTION - REPORTS	None known to exist.
MAINTENANCE OPERATION RECORDS	None known to exist.

APPENDIX B

PHOTOGRAPHS

(Taken on December 4, 1979)

RAMAPO LAKE DAM



Photo 1 - View of dam toward its left edge.



Photo 2 - Another view toward left edge of dam. Note horizontal and vertical misalignment, cracking and spalling of concrete curb.

RAMAPO LAKE DAM



Photo 3 - Detail of upstream concrete curb showing a void at its base.



Photo 4 - View of lake from dam. In foreground is a portion of the upstream concrete curb.

RAMAPO LAKE DAM



Photo 5 - View of dam toward its left edge. At lower left is the downstream concrete curb and a spillway and beyond that the discharge from another spillway.



Photo 6 - Detail of downstream side of the dam. Note spillway opening and trees growing on cobblestoned side slope.

RAMAPO LAKE DAM



Photo 7 - View of the two low-level control valves located on the downstream side of the dam. A spillway is visible at top center of photo.

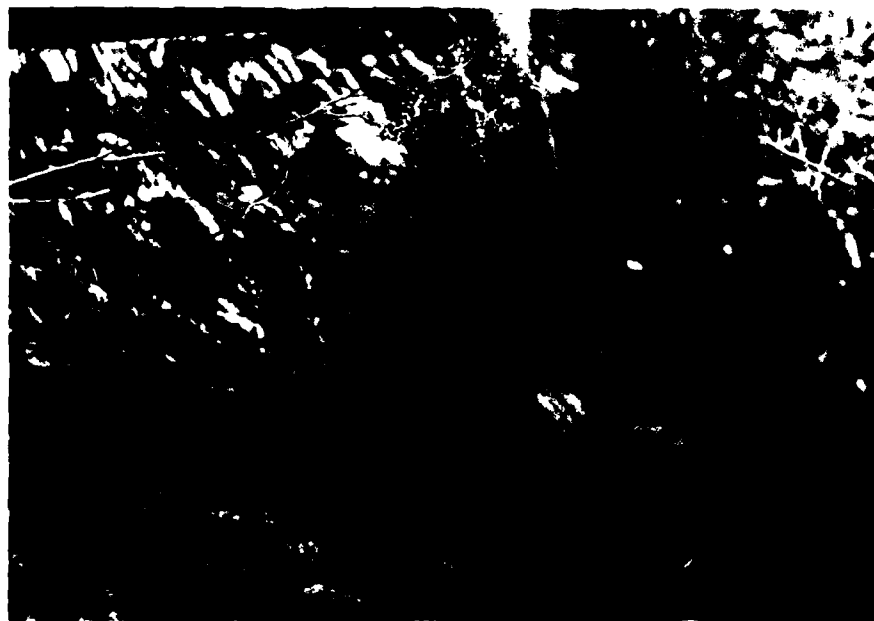


Photo 8 - Detail showing a crack in that low-level control valve which is closer to the crest of the dam.

RAMAPO LAKE DAM



Photo 9 - View of downstream from dam. A portion of the downstream concrete curb is visible at bottom of photo.

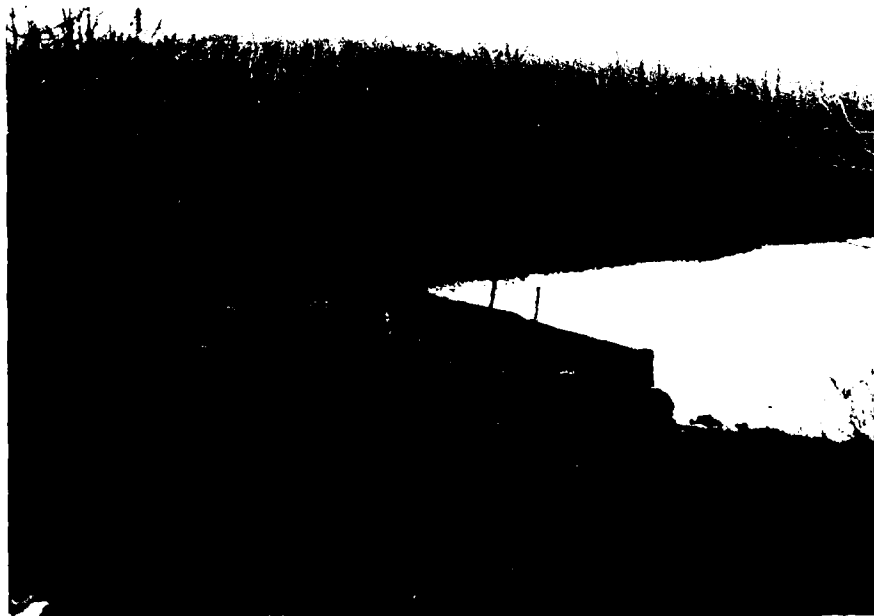


Photo 10 - View of dam toward its right edge. Note erosion of roadway near the beginning of the upstream concrete curb at lower right.

RAMAPO LAKE DAM



Photo 11 - View, toward dam, of the downstream channel.

APPENDIX C

SUMMARY OF ENGINEERING DATA

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

Name of Dam: RAMAPO LAKE DAM

Drainage Area Characteristics: 0.89 square miles

Elevation Top Normal Pool (Storage Capacity): 557.1 NGVD (24.0 acre-feet)

Elevation Top Flood Control Pool (Storage Capacity): N/A

Elevation Maximum Design Pool: 560.0 NGVD (SDF pool: 540 acre-feet)

Elevation Top Dam: 558.8 NGVD (406 acre-feet)

SPILLWAY CREST:

a. Elevation 556.7 NGVD

b. Type 5-10 feet x 1 foot concrete box culverts

c. Width 17.4 feet

d. Length 10 spillways at 5 ft. each = 50 ft.

e. Location Spillover Entire length of spillways.

f. No. and Type of Gates None

OUTLET WORKS:

a. Type 2 - 6 inch C.I.P.

b. Location 53.5 feet from the right end of the dam.

c. Entrance Inverts Unknown

d. Exit Inverts 552.9 NGVD & 555.6 NGVD

e. Emergency Draindown Facilities 2 gate valves 2-6 inch dia. C.I.P.

HYDROMETEOROLOGICAL GAGES:

a. Type None

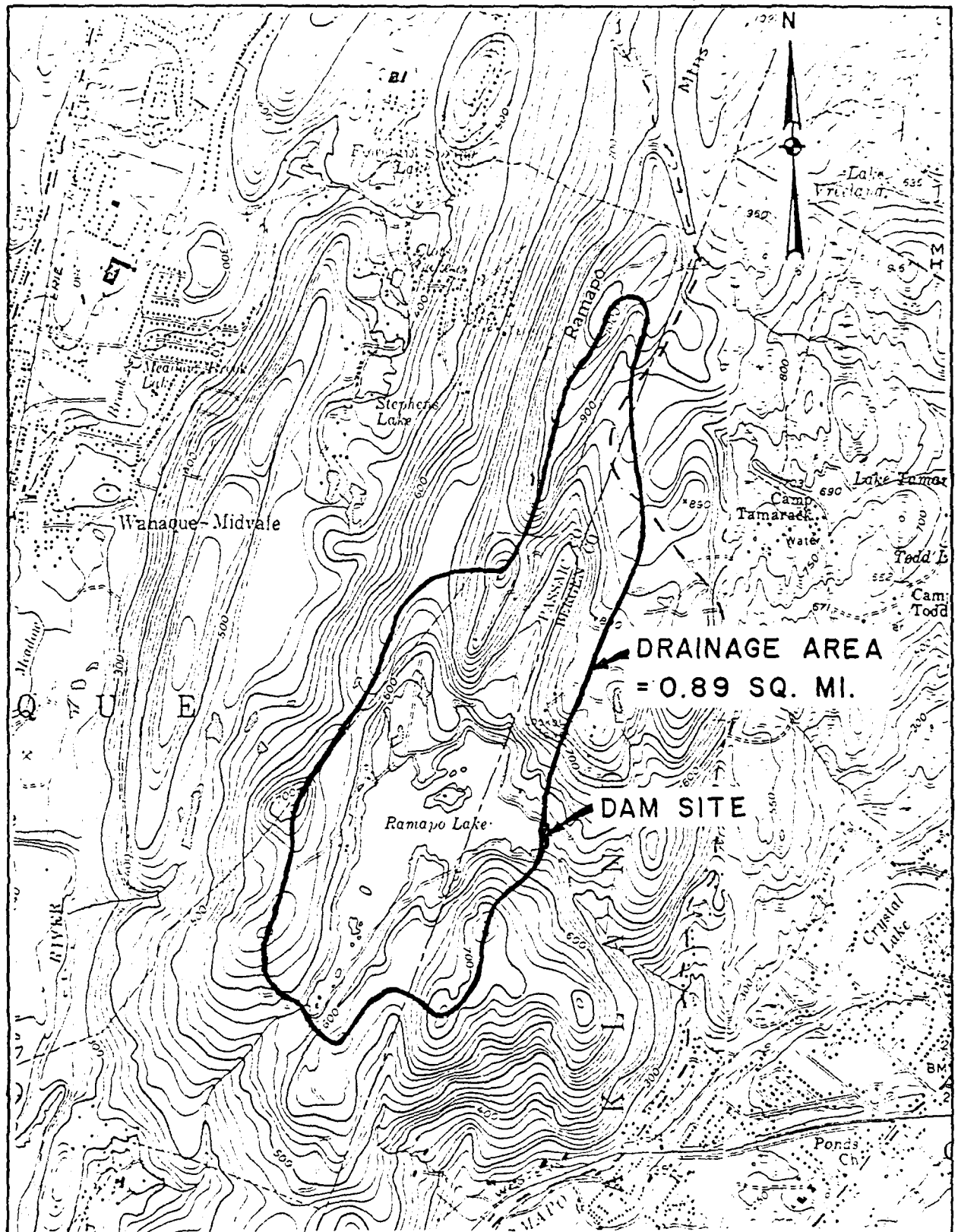
b. Location None

c. Records None

MAXIMUM NON-DAMAGING DISCHARGE: 245 cfs at elevation 558.8 NGVD

APPENDIX D

HYDROLOGIC COMPUTATIONS



2,000 0 2,000 4,000

Scale: 1" = 2,000 FT.

RAMAPO LAKE DAM
DRAINAGE BASIN

FREDERIC R. HARRIS, INC.
CONSULTING ENGINEERS

SUBJECT N.J. DAM SAFETY INSPECTION
RAMAPO LAKE DAM
COMPUTED BY SLC CHECKED BY ELK

SHEET NO. 1 OF 12
JOB NO. 10-AB2-01
DATE 1-21-80

Group XVII: RAMAPO LAKE DAM (N.J. 00216)

SIZE CLASSIFICATION

Surface Area of Main Impoundment 90 Acres
Average Depth of Lake 4
Structural Height of Dam 8 ft
Size Classification Small

HAZARD POTENTIAL CLASSIFICATION

Heavy Travelling Roadway, Skyline Drive, at D/S and
some houses along the stream.

Hazard Potential High
Recommended SDF $\frac{1}{2}$ PMF

HYDROLOGIC ANALYSIS

Flood Routing will be computed by HEC-1 DB program using
SCS Triangular Unit Hydrograph with curvilinear transformation.

D.A. = 0.57 SQ. MI.

FREDERIC R. HARRIS, INC.
CONSULTING ENGINEERS

SUBJECT N.J. DAM SAFETY INSPECTION
RAMAPO LAKE DAM
COMPUTED BY C.L.C. CHECKED BY B/L

SHEET NO 2 OF 12
JOB NO. 10-882-01
DATE 1-24-89

PRECIPITATION

From fig. 15 (Ref.: "DESIGN OF SMALL DAM"), the drainage area located at the boundary between Zone 1 & Zone 6. Probable max. precipitation = 25" for 6 Hrs. duration & 0.89 sq. mi. area basin.

<u>Duration</u>	<u>% of PMF</u>			Values are reduced by 20% to account for misalignment of storm isohyets
	<u>Zone 1</u>	<u>Zone 6</u>	<u>AVG</u>	
6	99	100	100	
12	111	109	110	
24	119	117	118	
48	127	126	127	

INFILTRATION DATA

Drainage area consists most of MMq

Hydrologic Soil Group

Initial Infiltration

Constant Infiltration

C/D

0.8 in/hr

0.08 in/hr

Ref. Engineering Soil Survey of N.J. Report 3. Passaic County by Rutgers University, 1951.

TIME OF CONCENTRATION

1) From Velocity & Water Course Length

	<u>Slope (%)</u>	<u>Velocity (fps)</u>	<u>Remark</u>
Overland Flow	$\frac{1000 - 680}{4800} = 6.7\%$	2.0	upper watershed Woodland
Stream Flow	$\frac{680 - 600}{1900} = 6.3\%$	3.0	natural channel not well defined

(Ref.: Design of Small Dam, p. 70.)

$$t_c = (4800/2 + 1900/3) / 2600 = 0.84 \text{ hr.}$$

2) From Nomograph "Design of Small Dam", p. 71.

$$\Delta H = 1000 - 560 = 440' \quad L = 6700'$$

$$S = 440 / 6700 = 6.3\%$$

$$t_c = 0.33 \text{ hr.}$$

3) From FAA Formula For surface flow (Airport Drainage)

$$t_c = \frac{1.8(1.1 - C)\sqrt{L}}{\sqrt{S}} = \frac{1.8(.3)\sqrt{6700}}{\sqrt{6.3/100}} = 1.06$$

4) Estimating t_c from velocity & water course length
Assuming travel through overland is at same velocity
as the stream channel

$$\frac{6700}{3(3600)} = 0.62 \text{ hr}$$

$$\text{Use } t_c = 0.71 \text{ hr}$$

$$t_{0.6} = 0.6 \times 0.71 = 0.43 \text{ hr} \quad \text{Use } t_{0.6} = 0.45 \text{ hr}$$

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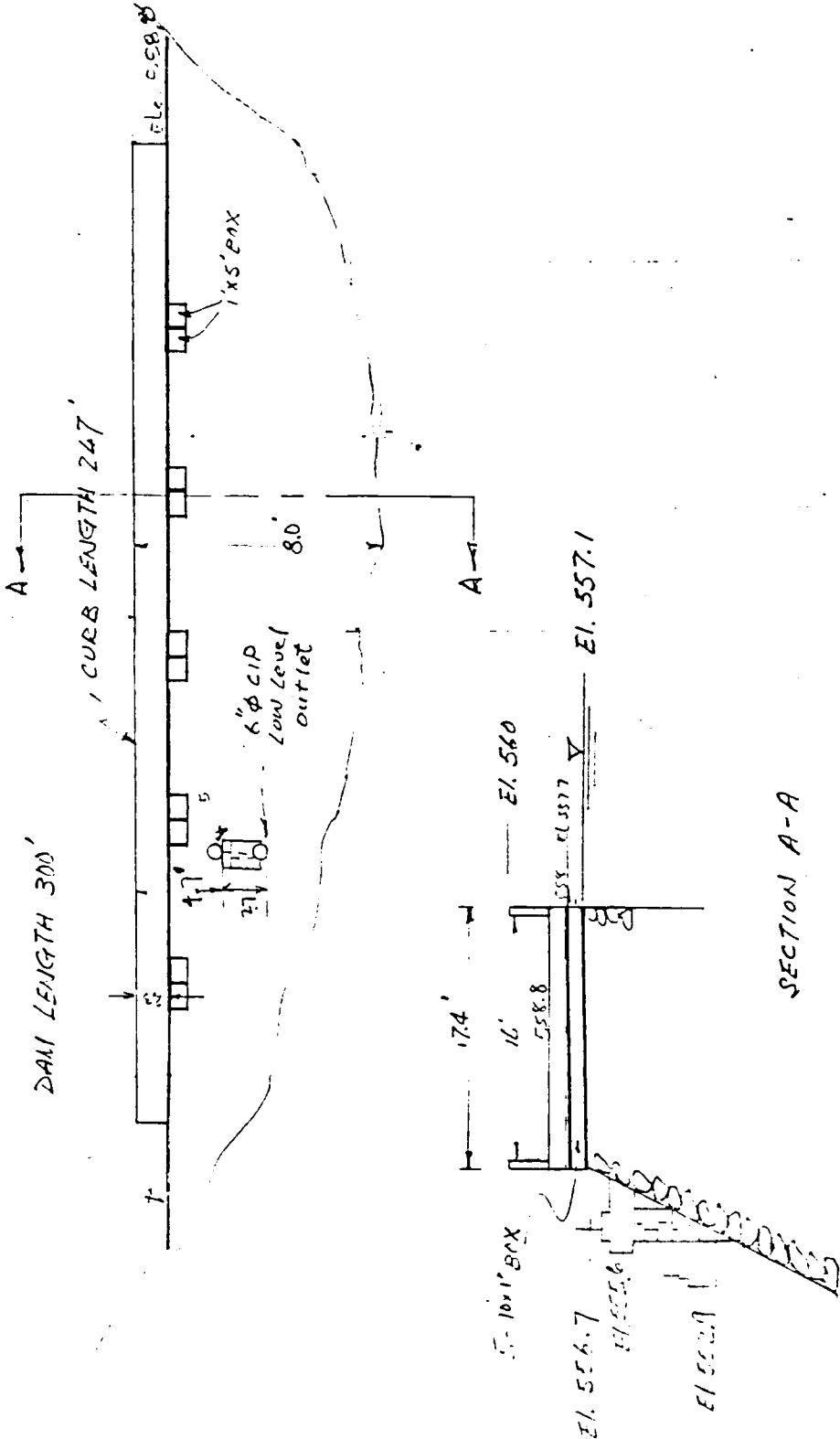
SUBJECT N. J. DAM SAFETY INSPECTION
RAMAPO LAKE DAM
COMPUTED BY C. L. C. CHECKED BY [Signature]

SHEET NO. 4 OF 12
JOB NO. 10-432-01
DATE 1-24-60

ELEVATION - AREA - CAPACITY RELATIONSHIP

DAM LENGTH 300' EL. (H) 560
N.E. (Ac.) 0 557.1 560
116.6

* Estimated El. @ the bottom of lake
Note: storage - capacity relationship developed for HEC-1 DB.



SECTION A-A

EL. 552.1

$L_3 = 247$ elev. 557.7
 $C_1 = 7.6$ pg. 5-16 Table 5-3, King & Brater

$L_2 = 53$ elev. 556.7
 $L_1 = 50$ elev. 556.8

$C_2 = 2.0$ } pg. 5-16 Table 5-3, King & Brater
 $C_3 = 2.0$

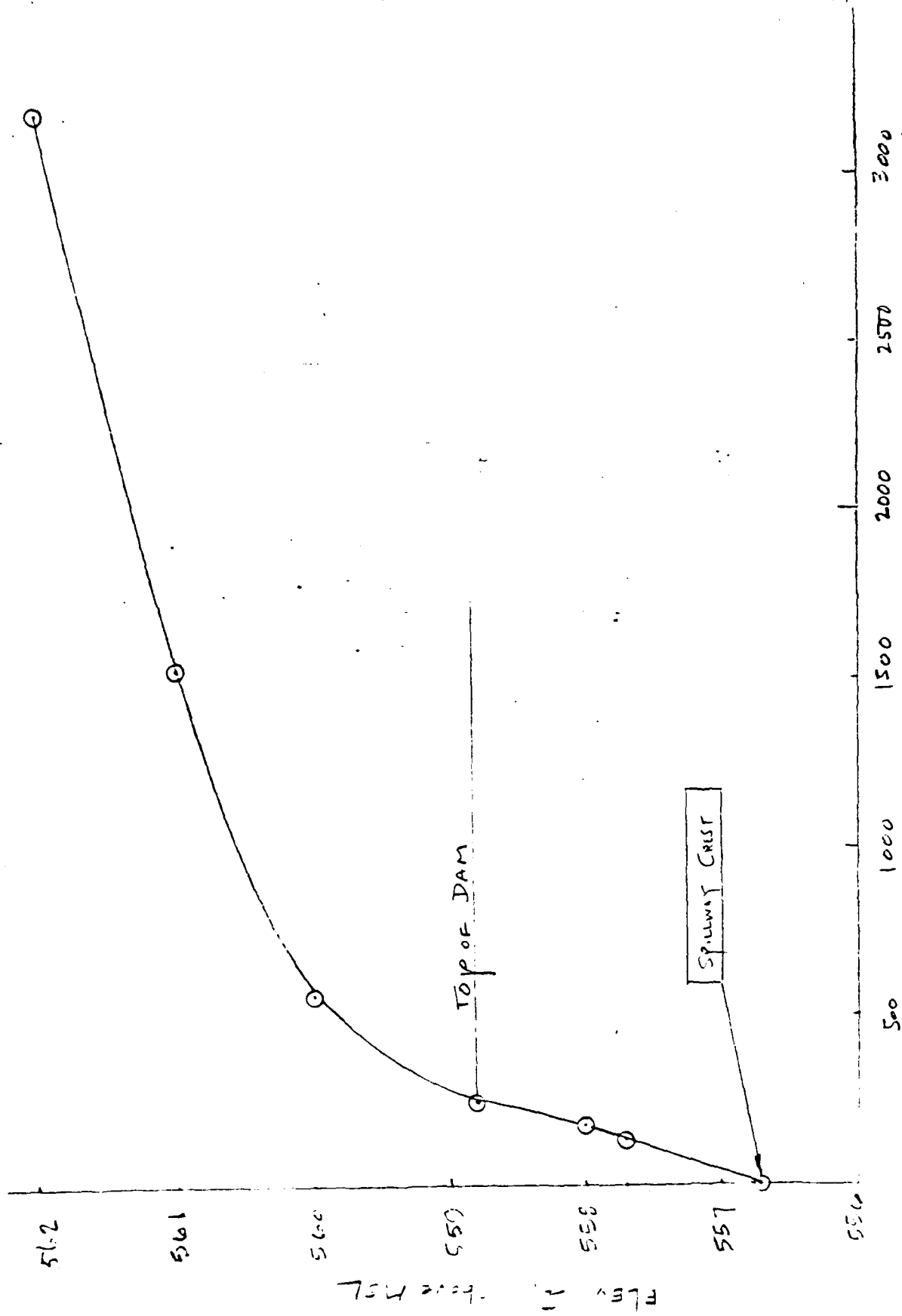
ELF	H_1	H_2	L_1	L_2	L_3	C_1	C_2	C_3	$Q = C_1 L_1 H_1^{1.5} + C_2 L_2 H_2^{1.5} + C_3 L_3 H_3^{1.5}$ $C_1 L_1 H_1^{1.5}$ UP TO $H_1 = 1'$ FOR $H_1 > 1'$ use Orifice Eq. for L_1 , for simplicity Fig B-12 of Small Dam will be used (Q_1) $Q = Q_1 + C_2 L_2 H_2^{1.5} + C_3 L_3 H_3^{1.5}$
556.7	0		50			7.6			130
557.7	1								175
558.8	1.815	0	50	53			2.0		245
560	3.33	1.2							375 + 181
561	4.242	2.2	50	53	247				430 + 450 + 642
562	5.353	3.2	50	52	247		2.0	2.0	475 + 789 + 1816
563	6.67	4.2	50	53	247		2.0	2.0	550 + 1186 + 3337

= 130
= 175
= 245
= 556
= 1522
= 1080
= 5073

PRC Harris, Inc.
CONSULTING ENGINEERS

SUBJECT NI Dam Improv. Group VII
Ramapo Lake Dam
COMPUTED BY P.K. CHECKED BY C.G.

SHEET NO. 6 OF 12
JOB NO. 16-422-21
DATE 2/4/80

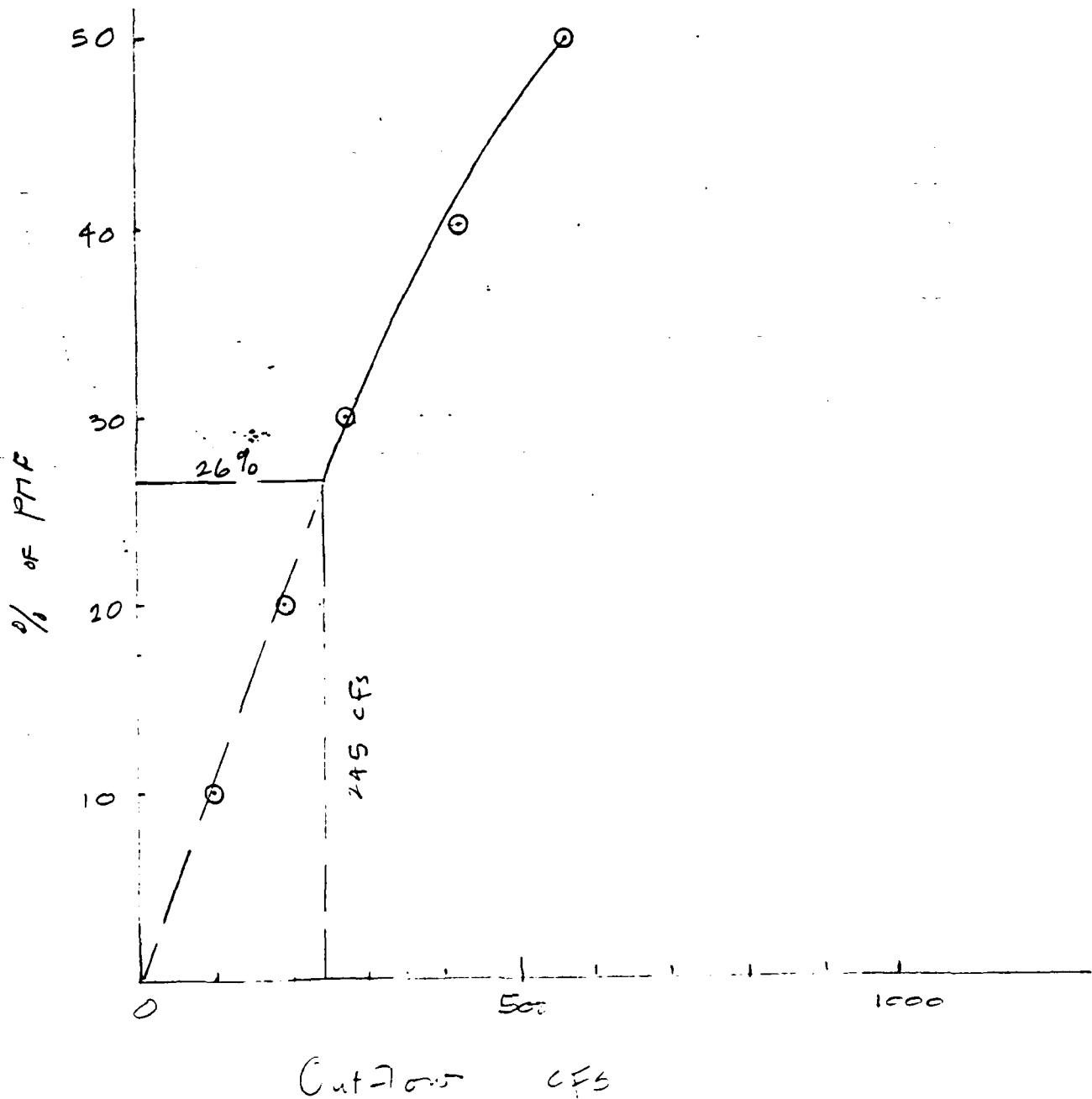


PRC Harris, Inc.
CONSULTING ENGINEERS

SUBJECT NJ Dam Safety Insp. Prog. Group III
Ramapo Lake
COMPUTED BY ET CHECKED BY C.C.

SHEET NO. 7 OF 12
JOB NO. 10-A83-01
DATE 2/6/80

Overtopping Potential



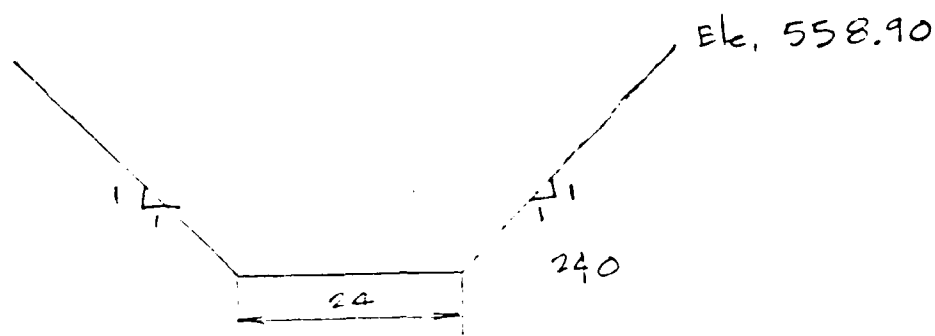
Overtopping of Dam occurs at elevation 558.6 with
 $Q = 245$ CFS ($\sim 26\%$ PMF or 52% of SDF)

Sensitivity Analysis Summary

Breach width ft	Side Slope	Breach bottom Elev.	Fail time	Initial Water Surface Elev.	Ratio of PMP	Fail Elev.	D/S Channel Max. Stage with failure ft.	Stage w/ no failure overtop ft.	Diff. in stage ft.
24	1	549.5	0.5	556.7	0.3	558.90	237.9	234.5	3.4
24	1	549.5	0.5	556.7	0.4	559.47	238.2	234.9	3.3
24	1	549.5	0.5	556.7	0.5	560.01	235.3	235.3	0

Breach Analysis

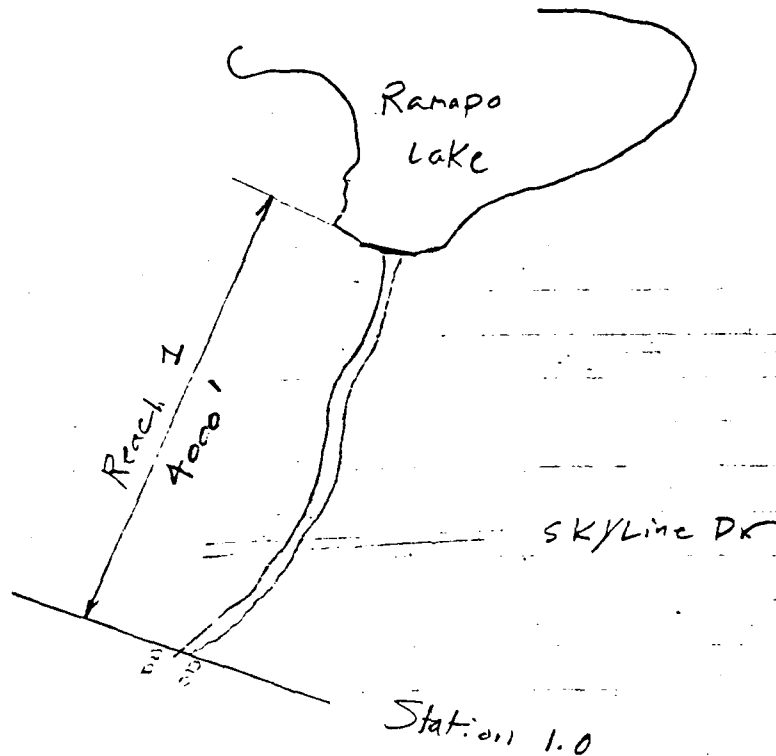
Based on Sensitivity Analysis (See above)
to develop when Lake stage to reach Elev. 558.9 @
30% PMP with fail time = 0.5 hr.



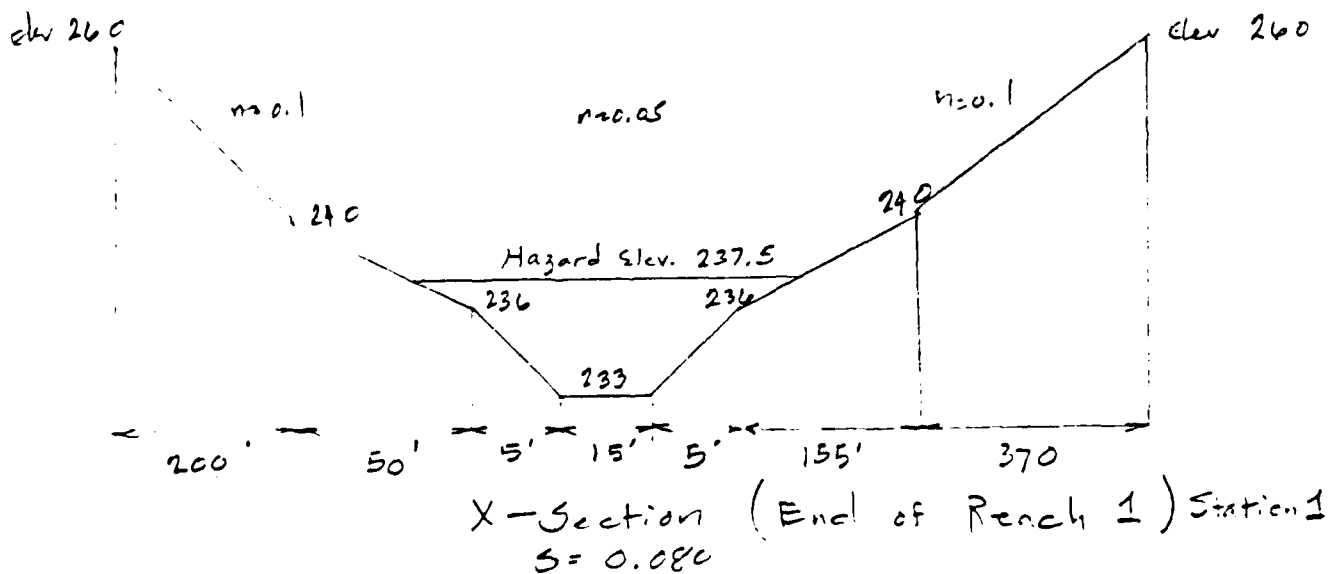
PRC Harris, Inc.
CONSULTING ENGINEERS

SUBJECT NJ Dam Safety Dep. Group III
Ramapo Lake
COMPUTED BY E.K. CHECKED BY C.C.

SHEET NO. 9 OF 12
JOB NO. 10-A83-01
DATE 2/6/80



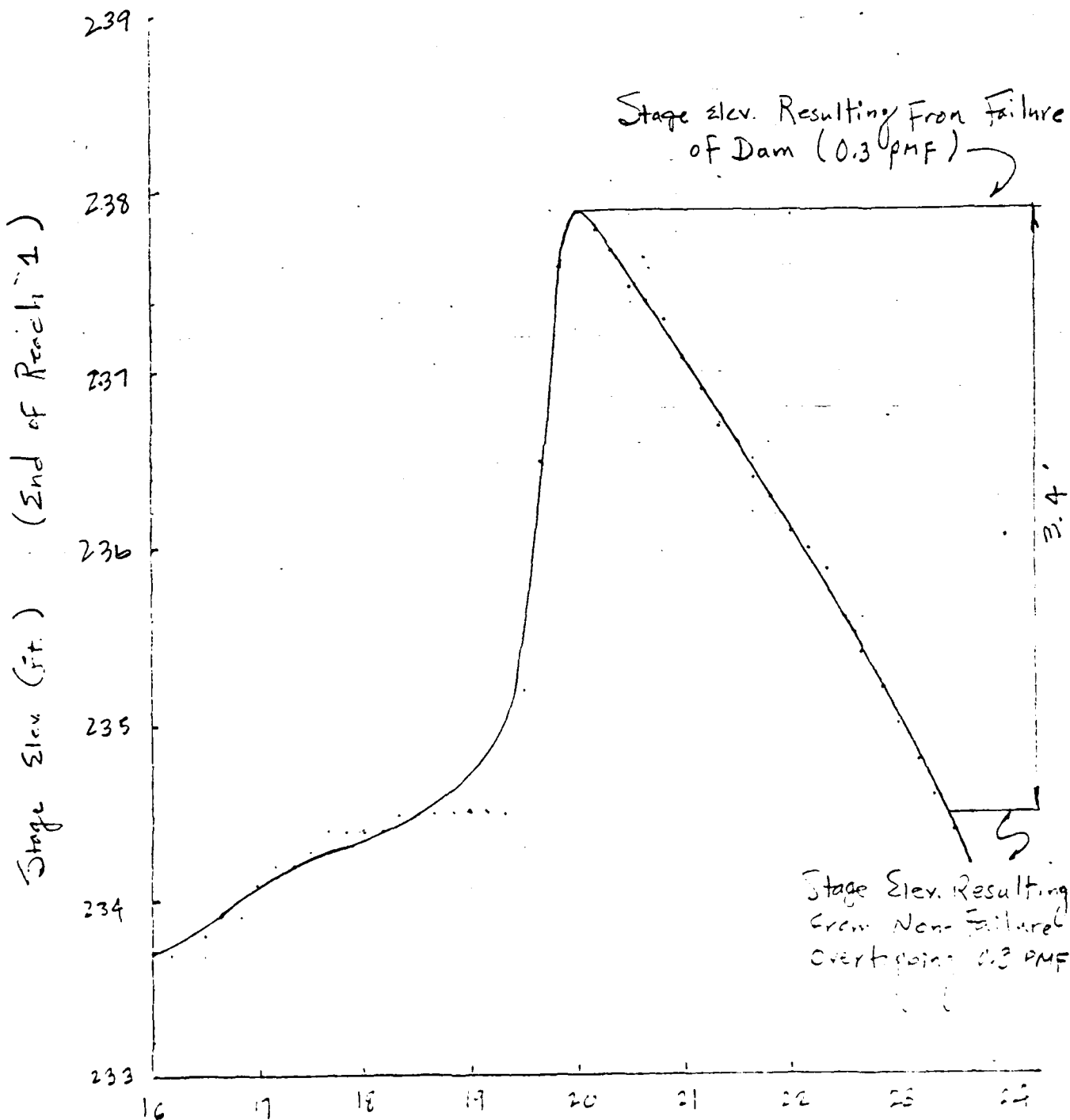
Assume bridge across the stream fails instantly upon impact of
Flood wave



PRC Harris, Inc.
CONSULTING ENGINEERS

SUBJECT NY Dam Safety Prog Group XVII
Ramapo Lake
COMPUTED BY BK CHECKED BY CC

SHEET NO 10 OF 12
JOB NO 10-A23-01
DATE 8/31/85



Drawdown computation

Assume the length of both of 6" c.p. = 30'

Assume $K_e = 0.5$, $K_{\text{valve}} = 0.19$ (full open)

$E = 0.00085$ and complete turbulent

$$\frac{E}{D} = 0.00170 \Rightarrow f = 0.023 \text{ (complete turb + rough pipe)}$$

$$H = \left(K_e + K_v + \frac{fL}{D} + 1 \right) \frac{V^2}{2g}$$
$$= (0.5 + 0.19 + 1.38 + 1) \frac{V^2}{2g} = 3.07 \frac{V^2}{2g}$$

$$V = 0.33 \sqrt{2gh} = 2.61 \sqrt{h}$$

$$Q = VA = 0.91 \sqrt{h}$$

$$D.A. = 0.89 \text{ sq. mi}$$

Normal elev to start draining @ Ele. 556.7

Assume tw. @ half diameter of outlet
= 552.9

Drawdown Computations: - continued

Res Ele	Area Acres	Ave Area	Vol. Ac-ft	Ave Rev	Q are cu ft drawn sec	$\frac{t}{1}$ time of drawdown $\frac{Vol \times 2.5}{1.57 \times Q}$	cul time hrs
556.7	81.23	74.1	51.87	516.35	1.52	413.64	413.64
556.	66.95	63.18	25.47	555.8	1.10	278.5	692.1
555.6	59.41	46.59	74.54	554.8	0.70	1290.7	1982.8
554	33.76	27.58	27.58	553.5	0.46	726.8	2709.6
553	21.39	20.85	2.08	552.95	0.11	18.9	2728.5
552.9	20.31						112.5

Time of complete drawdown with no inflow = 2729 hrs = 114 days

$$A_1 \approx \frac{A_2}{\left(\frac{n}{H_1} + 1\right)^2}$$

$$A_2 = 90 AC \text{ at elev } 557.1 \quad n + H_1 = 8'$$

UNIT HYDROGRAPH 15 END OF PERIOD ORIGINATES, TC= 0.00 HOURS, LAG= .45 VOL= 1.00 37.
165. 565. 802. 722. 488. 278. 171. 61. 61.
22. 13. 8. 5. 3.

END-OF-PERIOD FLOW									
MO. DA	HR. MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO. DA	HR. MN	PERIOD
1.01	1.0	1	.02	0.00	.02	1.	1.01	12.40	76
1.01	2.0	2	.02	0.00	.02	1.	1.01	12.50	77
1.01	3.0	3	.02	0.00	.02	1.	1.01	13.00	78
1.01	4.0	4	.02	0.00	.02	1.	1.01	13.10	79
1.01	5.0	5	.02	0.00	.02	1.	1.01	13.20	80
1.01	6.0	6	.02	0.00	.02	1.	1.01	13.30	81
1.01	7.0	7	.02	0.00	.02	1.	1.01	13.40	82
1.01	8.0	8	.02	0.00	.02	1.	1.01	13.50	83
1.01	9.0	9	.02	0.00	.02	0.	1.01	14.00	84
1.01	10.0	10	.02	0.00	.02	0.	1.01	14.10	85
1.01	11.0	11	.02	0.00	.02	0.	1.01	14.20	86
1.01	12.0	12	.02	0.00	.02	0.	1.01	14.30	87
1.01	13.0	13	.02	0.00	.02	0.	1.01	14.40	88
1.01	14.0	14	.02	0.00	.02	0.	1.01	14.50	89
1.01	15.0	15	.02	0.00	.02	0.	1.01	15.00	90
1.01	16.0	16	.02	0.00	.02	0.	1.01	15.10	91
1.01	17.0	17	.02	0.00	.02	0.	1.01	15.20	92
1.01	18.0	18	.02	0.00	.02	0.	1.01	15.30	93
1.01	19.0	19	.02	0.00	.02	0.	1.01	15.40	94
1.01	20.0	20	.02	0.00	.02	0.	1.01	15.50	95
1.01	21.0	21	.02	0.00	.02	0.	1.01	16.00	96
1.01	22.0	22	.02	0.00	.02	0.	1.01	16.10	97
1.01	23.0	23	.02	0.00	.02	0.	1.01	16.20	98
1.01	24.0	24	.02	0.00	.02	0.	1.01	16.30	99
1.01	25.0	25	.02	0.00	.02	0.	1.01	16.40	100
1.01	26.0	26	.02	0.00	.02	0.	1.01	16.50	101
1.01	27.0	27	.02	0.00	.02	0.	1.01	17.00	102
1.01	28.0	28	.02	0.00	.02	0.	1.01	17.10	103
1.01	29.0	29	.02	0.00	.02	0.	1.01	17.20	104
1.01	30.0	30	.02	0.00	.02	0.	1.01	17.30	105
1.01	31.0	31	.02	0.00	.02	0.	1.01	17.40	106
1.01	32.0	32	.02	0.00	.02	0.	1.01	17.50	107
1.01	33.0	33	.02	0.00	.02	0.	1.01	18.00	108
1.01	34.0	34	.02	0.00	.02	0.	1.01	18.10	109
1.01	35.0	35	.02	0.00	.02	0.	1.01	18.20	110
1.01	36.0	36	.02	0.00	.02	0.	1.01	18.30	111
1.01	37.0	37	.06	0.00	.06	0.	1.01	18.40	112
1.01	38.0	38	.06	0.00	.06	0.	1.01	18.50	113
1.01	39.0	39	.06	.01	.05	2.	1.01	19.00	114
1.01	40.0	40	.06	.01	.05	2.	1.01	19.10	115
1.01	41.0	41	.06	.01	.05	2.	1.01	19.20	116
1.01	42.0	42	.06	.01	.05	2.	1.01	19.30	117
1.01	43.0	43	.06	.01	.05	2.	1.01	19.40	118
1.01	44.0	44	.06	.01	.05	2.	1.01	19.50	119
1.01	45.0	45	.06	.01	.05	2.	1.01	20.00	120
1.01	46.0	46	.06	.01	.05	2.	1.01	20.10	121
1.01	47.0	47	.06	.01	.05	2.	1.01	20.20	122
1.01	48.0	48	.06	.01	.05	2.	1.01	20.30	123
1.01	49.0	49	.06	.01	.05	2.	1.01	20.40	124
1.01	50.0	50	.06	.01	.05	2.	1.01	20.50	125
1.01	51.0	51	.06	.01	.05	2.	1.01	21.00	126
1.01	52.0	52	.06	.01	.05	2.	1.01	21.10	127
1.01	53.0	53	.06	.01	.05	2.	1.01	21.20	128
1.01	54.0	54	.06	.01	.05	2.	1.01	21.30	129
1.01	55.0	55	.06	.01	.05	2.	1.01	21.40	130
1.01	56.0	56	.06	.01	.05	2.	1.01	21.50	131
1.01	57.0	57	.06	.01	.05	2.	1.01	22.00	132
1.01	58.0	58	.06	.01	.05	2.	1.01	22.10	133
1.01	59.0	59	.06	.01	.05	2.	1.01	22.20	134
1.01	60.0	60	.06	.01	.05	2.	1.01	22.30	135
1.01	61.0	61	.06	.01	.05	2.	1.01	22.40	136
1.01	62.0	62	.06	.01	.05	2.	1.01	22.50	137
1.01	63.0	63	.06	.01	.05	2.	1.01	23.00	138
1.01	64.0	64	.06	.01	.05	2.	1.01	23.10	139
1.01	65.0	65	.06	.01	.05	2.	1.01	23.20	140
1.01	66.0	66	.06	.01	.05	2.	1.01	23.30	141
1.01	67.0	67	.06	.01	.05	2.	1.01	23.40	142
1.01	68.0	68	.06	.01	.05	2.	1.01	23.50	143
1.01	69.0	69	.06	.01	.05	2.	1.01	24.00	144
1.01	70.0	70	.06	.01	.05	2.	1.01	24.10	145
1.01	71.0	71	.06	.01	.05	2.	1.01	24.20	146
1.01	72.0	72	.06	.01	.05	2.	1.01	24.30	147
1.01	73.0	73	.06	.01	.05	2.	1.01	24.40	148
1.01	74.0	74	.06	.01	.05	2.	1.01	24.50	149
1.01	75.0	75	.06	.01	.05	2.	1.01	25.00	150
1.01	76.0	76	.06	.01	.05	2.	1.01	25.10	151
1.01	77.0	77	.06	.01	.05	2.	1.01	25.20	152
1.01	78.0	78	.06	.01	.05	2.	1.01	25.30	153
1.01	79.0	79	.06	.01	.05	2.	1.01	25.40	154
1.01	80.0	80	.06	.01	.05	2.	1.01	25.50	155
1.01	81.0	81	.06	.01	.05	2.	1.01	26.00	156
1.01	82.0	82	.06	.01	.05	2.	1.01	26.10	157
1.01	83.0	83	.06	.01	.05	2.	1.01	26.20	158
1.01	84.0	84	.06	.01	.05	2.	1.01	26.30	159
1.01	85.0	85	.06	.01	.05	2.	1.01	26.40	160
1.01	86.0	86	.06	.01	.05	2.	1.01	26.50	161
1.01	87.0	87	.06	.01	.05	2.	1.01	27.00	162
1.01	88.0	88	.06	.01	.05	2.	1.01	27.10	163
1.01	89.0	89	.06	.01	.05	2.	1.01	27.20	164
1.01	90.0	90	.06	.01	.05	2.	1.01	27.30	165
1.01	91.0	91	.06	.01	.05	2.	1.01	27.40	166
1.01	92.0	92	.06	.01	.05	2.	1.01	27.50	167
1.01	93.0	93	.06	.01	.05	2.	1.01	28.00	168
1.01	94.0	94	.06	.01	.05	2.	1.01	28.10	169
1.01	95.0	95	.06	.01	.05	2.	1.01	28.20	170
1.01	96.0	96	.06	.01	.05	2.	1.01	28.30	171
1.01	97.0	97	.06	.01	.05	2.	1.01	28.40	172
1.01	98.0	98	.06	.01	.05	2.	1.01	28.50	173
1.01	99.0	99	.06	.01	.05	2.	1.01	29.00	174
1.01	100.0	100	.06	.01	.05	2.	1.01	29.10	175
1.01	101.0	101	.06	.01	.05	2.	1.01	29.20	176
1.01	102.0	102	.06	.01	.05	2.	1.01	29.30	177
1.01	103.0	103	.06	.01	.05	2.	1.01	29.40	178
1.01	104.0	104	.06	.01	.05	2.	1.01	29.50	179
1.01	105.0	105	.06	.01	.05	2.	1.01	30.00	180
1.01	106.0	106	.06	.01	.05	2.	1.01	30.10	181
1.01	107.0	107	.06	.01	.05	2.	1.01	30.20	182
1.01	108.0	108	.06	.01	.05	2.	1.01	30.30	183
1.01	109.0	109	.06	.01	.05	2.	1.01	30.40	184
1.01	110.0	110	.06	.01	.05	2.	1.01	30.50	185
1.01	111.0	111	.06	.01	.05	2.	1.01	31.00	186
1.01	112.0	112	.06	.01	.05	2.	1.01	31.10	187
1.01	113.0	113	.06	.01	.05	2.	1.01	31.20	188
1.01	114.0	114	.06	.01	.05	2.	1.01	31.30	189
1.01	115.0	115	.06	.01	.05	2.	1.01	31.40	190
1.01	116.0	116	.06	.01	.05	2.	1.01	31.50	191
1.01	117.0	117	.06	.01	.05	2.	1.01	32.00	192
1.01	118.0	118	.06	.01	.05	2.	1.01	32.10	193
1.01	119.0	119	.06	.01	.05	2.	1.01	32.20	194
1.01	120.0	120	.06	.01	.05	2.	1.01	32.30	195
1.01	121.0	121	.06	.01	.05	2.	1.01	32.40	196
1.01	122.0	122	.06	.01	.05	2.	1.01	32.50	197
1.01	123.0	123	.06	.01	.05	2.	1.01	33.00	198
1.01	124.0	124	.06	.01	.05	2.	1.01	33.10	199
1.01	125.0	125	.06	.01	.05	2.	1.01	33.20	200
1.01	126.0	126	.06	.01	.05	2.	1.01	33.30	201
1.01	127.0	127	.06	.01	.05	2.	1.01	33.40	202
1.01	128.0	128	.06	.01	.05	2.	1.01	33.50	203
1.01	129.0	129	.06	.01	.05	2.	1.01	34.00	204
1.01	130.0	130	.06	.01	.05	2.	1.01	34.10	205
1.01	131.0	131	.06	.01	.05	2.	1.01	34.20	206
1.01	132.0	132	.06	.01	.05	2.	1.01	34.30	207
1.01	133.0	133	.06	.01	.05	2.	1.01	34.40	208
1.01	134.0	134	.06	.01	.05	2.	1.01	34.50	209
1.01	135.0	135	.06	.01	.05	2.	1.01	35.00	210
1.01	136.0	136	.06	.01	.05	2.	1.01	35.10	211
1.01	137.0	137	.06	.01	.05	2.	1.01	35.20	212
1.01	138.0	138	.06	.01	.05	2.	1.01	35.30	213
1.01	139.0	139	.06	.01	.05	2.	1.01	35.40	214
1.01	140.0	140	.06	.01	.05	2.	1.01	35.50	215
1.01	141.0	141	.06	.01	.05	2.	1.01	36.00	216
1.01	142.0	142	.06	.01	.05	2.	1.01	36.10	217
1.01	143.0	143	.06	.01	.05	2.	1.01	36.20	218
1.01	144.0								

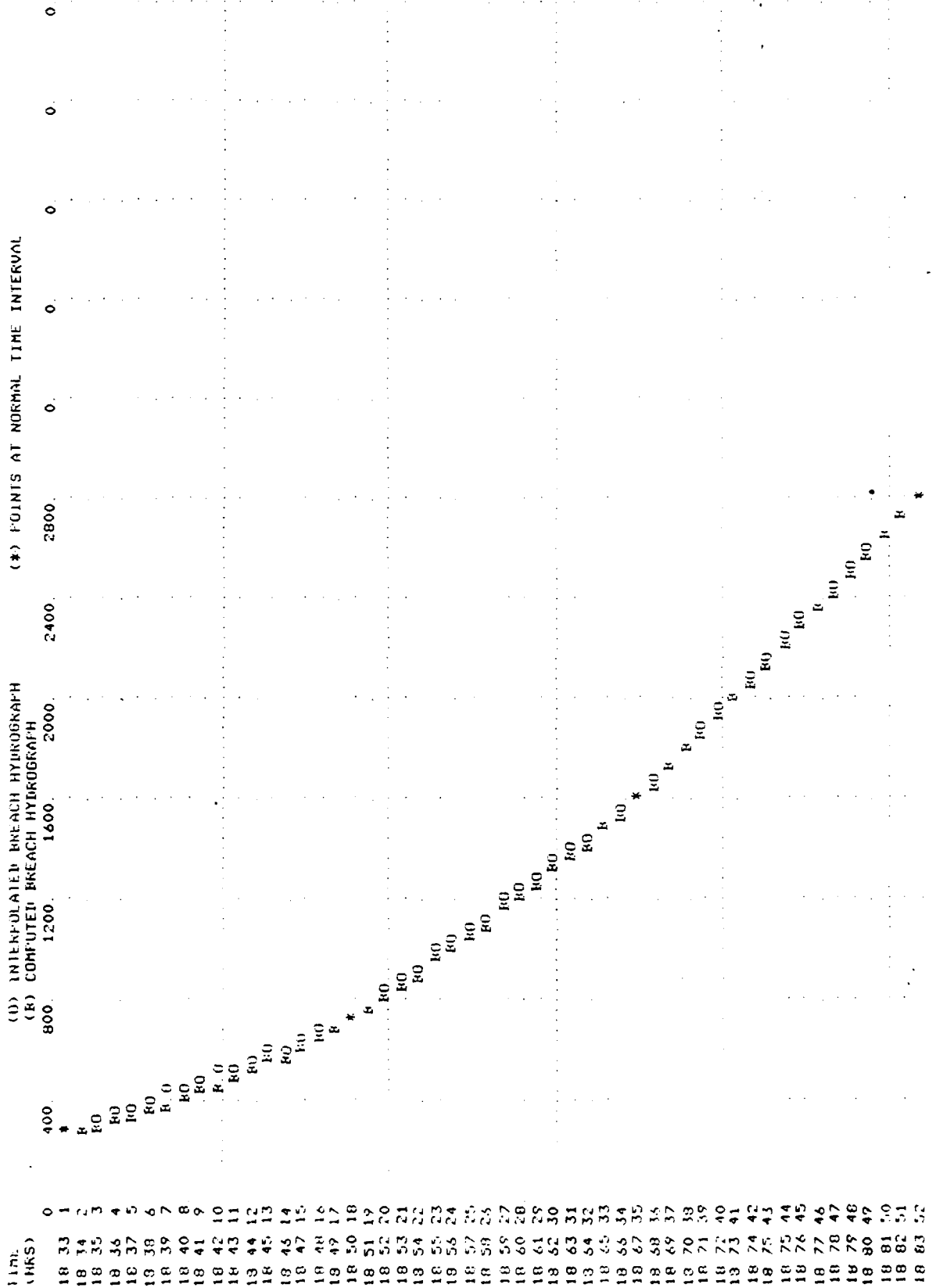
PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS				
				RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5
				.50	.40	.30	.20	.10
HYDROGRAPH AT	LANE	.89 (2.31)	1	2513	2011	1508	1005	503
				(71.17)	(56.93)	(42.70)	(28.47)	(14.23)
ROUTED TO	DAM	.89 (2.31)	1	564	419	271	191	99
				(15.98)	(11.87)	(7.68)	(5.41)	(2.82)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	ELEVATION STORAGE OUTFLOW	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM	TIME UP HOURS	MAX OUTFLOW HOURS	TIME UP HOURS	FAILURE HOURS
		556.70	556.70	558.80				
		206	206	406				
		0	0	245				
RATIO OF FHF	MAXIMUM RESERVOIR W.S. ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	MAX OUTFLOW HOURS	TIME UP HOURS	FAILURE HOURS
50	560.01	1.21	540	564	7.67	18.17	0.00	0.00
40	559.47	.67	479	419	5.67	18.33	0.00	0.00
30	558.90	.10	416	271	1.83	18.33	0.00	0.00
20	558.18	0.00	343	191	0.00	18.33	0.00	0.00
10	557.47	0.00	273	99	0.00	18.33	0.00	0.00

STATION 100



HYDROGRAPH ROUTING

CHANNEL ROUTING

ISTAR REACH1	ICOMP 1	ILCON 0	ITAPE 0	JFLT 0	JFRT 0	INAML 1	ISTAGE 0	IAUTO 0
ALL PLANS HAVE SAME ROUTING DATA								
W LOSS 0 0	CLOSS 0.00	AVG 0.00	IKES 1	ISAME 1	IFMT 0	ISIR 0		
NSIFS 1	NSTDL 0	LAG 0	AMSNN 0	X 0	ISK 0	STORA 0	ISFRAT 0	

AUXILIARY CHANNEL ROUTING

QNC(1)	QNC(2)	QNC(3)	ELNUT	ELMAX	RUNTH	SEL
1000	0500	1000	233.0	260.0	4000	08000

CROSS SECTION COORDINATES--STA-ELEV, STA-ELEV---EIC

1000 00	260 00	1300 00	240 00	1350 00	236 00	1355 00	233 00	233 00
1375 00	236 50	1530 00	240 00	1900 00	260 00			

STORAGE	0 00	2 24	5 06	10 39	25 39	50 91	84 49	124 28	222 10
	280 93	345 57	416 42	493 48	576 76	666 24	761 94	863 86	1006 32
OUTFLOW	0 00	233 61	777 39	1765 29	3667 37	7015 84	12340 11	19545 05	40141 99
	53828 08	69969 44	88711 28	110196 10	134563 62	161950 80	192491 91	226318 70	263560 52
STAGE	233 00	234 42	235 84	237 26	238 68	240 11	241 53	242 95	245 79
	247 21	248 63	250 05	251 47	252 89	254 32	255 74	257 16	258 58
FLOW	0 00	233 61	777 39	1765 29	3667 37	7015 84	12340 11	19545 05	40141 99
	53828 08	69969 44	88711 28	110196 10	134563 62	161950 80	192491 91	226318 70	263560 52

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM	
ELEVATION STORAGE OUTFLOW	556.70	556.70	558.80	
	206.	206.	406.	
	0.	0.	245.	

	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
RATIO OF PMF	30	416.	271.	1.83	18.33	0.00

PLAN 2

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM	
ELEVATION STORAGE OUTFLOW	556.70	556.70	558.80	
	206.	206.	406.	
	0.	0.	245.	

	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
RATIO OF PMF	30	416.	2793	1.27	18.83	18.33

PLAN 1 STATION REACH

RATIO	MAXIMUM FLOW, CFS	MAXIMUM STAGE, FT	TIME HOURS
30	271.	234.5	18.50

PLAN 2 STATION REACH

RATIO	MAXIMUM FLOW, CFS	MAXIMUM STAGE, FT	TIME HOURS
30	2658.	237.9	19.00

 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION JULY 1978
 LAST MODIFICATION 26 FEB 79
